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ABSTRACT

Abstracts of most of the papers presented at the 58th annual meeting of the National Association for Research in Science Teaching (NARST) have been collected in this publication. These papers related to such areas as: science curriculum development, design, and implementation; science test development; factors influencing student science achievement; achievement in college science, biology, and chemistry; science teacher education; aptitude treatment interaction studies; concept mapping; science concept formation; computer simulations; problem solving in science and in chemistry; student attitudes; logical thinking; meta analysis; formal thought; computer applications in science; and various research techniques. (JN)

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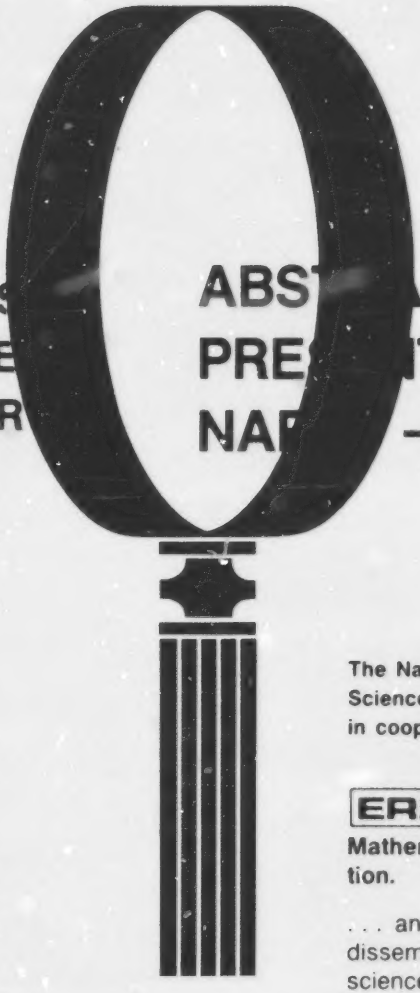
ABSTRACTS OF PRESENTED PAPERS, NARST — 1985



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ABSTRACTS OF PRESENTED PAPERS

NATIONAL ASSOCIATION FOR

RESEARCH IN SCIENCE TEACHING

58TH ANNUAL NARST CONFERENCE

1985

French Lick Springs, Indiana

April 15-18, 1985

Clearinghouse for Science, Mathematics,
and Environmental Education
The Ohio State University
1200 Chambers Road, Room 310
Columbus, OH 43212

December 31, 1984

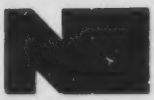
PREFACE

The ERIC Clearinghouse for Science, Mathematics and Environmental Education has cooperated with the National Association for Research in Science Teaching to provide abstracts of most of the papers presented at the 58th annual conference in French Lick Springs, Indiana, April 15-18, 1985.

All persons who had papers or symposia accepted were invited to submit abstracts for inclusion in this publication. Some editing was done by the ERIC staff to provide a general format for the abstracts. Special recognition should be given to Dr. David P. Butts; Dr. Rodney L. Doran, Research Coordinator; and the NARST Program Committee who obtained the abstracts and organized the program.

Many of the papers will be published in journals or made available through the ERIC system. These will be announced through Resources in Education, Current Index to Journals in Education, and other publications of the ERIC system.

Patricia E. Blosser,
Stanley L. Helgeson,
Editors



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ABSTRACT

The research to be reported was undertaken to investigate various methods of presentation of a computer based science simulations as they relate to student content knowledge of the simulation concepts. Three treatment groups were used in the study; (1) two students per computer interacting with the simulation, (2) a total class presentation of the computer simulation, (3) a non-computer game type presentation of the simulation concepts. Students content knowledge was measured by a paper and pencil test of fourteen items immediately after the presentation and six weeks later.

No statistically significant differences were found between the treatment groups, although there was a trend for higher scores for the total class presentation group on the immediate posttest multiple choice content items. However, females did less well than males on the multiple choice content items of the test. A sex by treatment group interaction was significnat for the delayed posttest with females performing better than males in the total class presentation method but less well in the paired student method.

THE EFFECTIVENESS OF USING A MICROCOMPUTER SIMULATION ON JUNIOR HIGH SCHOOL STUDENTS' UNDERSTANDING OF THE VOLUME DISPLACEMENT CONCEPT

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ABSTRACT

The purpose of this study was to compare the effectiveness of microcomputer simulated experiences with that of parallel instruction involving hands-on laboratory experiences for teaching the concept of volume displacement to junior high school students. This study also assessed the differential effect on students' understanding of the volume displacement concept using sex of the students as another independent variable. This study in addition, compared the degree of retention, after 45 days, of both treatment groups.

Girls and boys were randomly assigned to experimental and control groups during each of five periods of the day. Posttests and retention tests were given to both groups, and the data were analyzed using a 3-way analysis of variance. It was found that computer simulated experiences were as effective as hands-on laboratory experiences, and that males, having had hands-on laboratory experiences, performed better on the posttest than females having had the hands-on laboratory experiences. There were no significant differences in performance when comparing males with females using the computer simulation in the learning of the displacement concept. This study also showed that there were no significant differences in the retention levels when the retention scores of the computer simulation groups were compared to those that had the hands-on laboratory experiences; however, an ANOVA of the retention test scores revealed that males in both treatment conditions retained knowledge of volume displacement better than did females.

This study suggests that computer simulated experiences on some topics of science could be used in place of hands-on laboratory experiences with an expectation of equal performance levels by students. It also suggests that learning of certain topics in science can be learned in a shorter period of time than is required for hands-on laboratory experiences related to these

topics. Another implication of this study is that a computer program might be used in place of more expensive materials in some laboratory experiments. Therefore, computer simulations in science education could be efficient and cost-effective as well.

Session A-1

COMPUTER SIMULATIONS AND THE TRANSITION FROM CONCRETE MANIPULATION OF OBJECTS TO ABSTRACT THINKING

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ABSTRACT

This study explores the learning model which suggests that a concept is acquired first through manipulation of concrete objects followed by transformation of the concrete objects into semi-concrete representations, followed by internalization of the concept through abstract representations.

Microcomputer simulations of manipulative activities were used to determine how children differ in their use of science-process skills and concepts when using the simulations compared to using the concrete materials, or a combination of simulations and concrete materials.

The sample for the study included a total of 113 children distributed according to male and female, 2nd and 4th grade level, and socio-cultural site. The treatment condition consisted of three levels based upon the proportion of activities using concrete objects to those using computer simulations (concrete only, concrete and computer, computer only).

The criterion measures assessed the children's ability to: recognize and duplicate a design, recognize and extend a pattern, and locate objects in space.

A multivariate analysis of variance was used to determine the influence of the computer simulations on concept development as compared to the use of concrete materials. Differential effects were tested in terms of socio-cultural background, gender, and grade level. The results indicated that:

1. Fourth graders performed better than second graders.

2. Rural, white children performed better than suburban, black children with activities involving the computer.

3. Rural, white girls performed better than suburban, black girls using concrete-only activities.

4. Rural, white boys using activities involving the computer performed better than suburban, black girls using concrete-only activities.

Session A-2

SCIENCE EDUCATION: DEFINITIONS AND IMPLICATIONS FOR RESEARCH

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ABSTRACT

The purpose of this symposium is to explore the implications of the following definitions for science teaching and related research.

Definition 1

Science education is the discipline concerned with the study of the impact of science upon society as well as the impact of society upon science.

Definition 2

Science education is the discipline concerned with discovering, developing, and evaluating improved methods and materials to teach science--i.e., the quest for knowledge as well as the knowledge generated by that quest.

Session A-3

AN EXAMINATION OF SCIENCE FAIR JUDGING RESULTS

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ABSTRACT

Recently, science fairs, which had been reduced in size or eliminated by many schools, have shown renewed vigor. This paper revisits an old issue, the fairness of the judging system, through a post hoc analysis of the judging results of four science fairs. The nearly 1200 projects involved 3000 project scorings by judges. The judges' scorings were submitted to analyses which included the following: examination of score errors made by judges and uncorrected by the fair staff, descriptive statistics for each data set, correlation of total score to total score for each project; examination of judge to judge differences in scoring, and exploration of alternative techniques of combining scoes.

A scoring error rate of 3-5% was found. This error rate existed even through each fair had double checked the judges' scoring. Correlation of scores for the same projects ranged from .21 to .55. Higher correlations occurred in fairs having more detailed instructions to judges. All of the correlations were significant well beyond the .01 level. However, these correlations can be viewed as the reliability for the scoring of a project. At these magnitudes they illustrate the unreliability of the judging process. Examples of the judge to judge differences in scoring were given.

An alternative system for combining judges' scores by using standard scores derived from each judge's set of scores was explored. This system produced a different ranking of projects than the ranking of raw scores.

Judging systems which simply add raw scores of different judges must be suspect. Alternative schemes, such as the standard score method used herein, will give different results from the simple addition of scores, yet are based on assumptions (all judges will be evaluating an "average" set of projects) which are unlikely to be true. Other schemes, such as asking judges to score by points and to acknowledge a general level of award (top 10%, top 25%, etc.) are likely to provide yet different results.

Science fair judging committees need to be aware of the shortcomings of whatever data manipulation and analysis techniques they use and be willing to make accommodation as necessary. It is

possible that modern statistical techniques would help reduce the ambiguity and unfairness of existing systems.

Session A-3

CHARACTERISTICS AND NEEDS ASSESSMENTS OF SCIENCE TEACHERS IN MASSACHUSETTS

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ABSTRACT

The purpose of this research study was: (1) to provide a description and evaluation of the Boston University Science Fellows Program for outstanding high school science teachers, (2) to provide a profile of the science teachers of Massachusetts for evaluation of staffing needs, and (3) to compare the science teacher characteristics of the Boston University Science Fellows with science teachers of Massachusetts and other states.

Preliminary analysis of incomplete data indicate that science teachers are teaching outside their principal field of preparation, there is a shortage of certified physics teachers, a lack of updating of existing science teachers, and an increase in the number of science teachers who are expected to reach retirement age within the next several years.

The conclusions should allow (1) an evaluation of the characteristics and staff development needs of existing science teachers, (2) an evaluation of certification standards and teacher evaluation practices, and (3) a model to recognize successful science teachers.

Session A-3

SCHOOL VARIABLES AND ACHIEVEMENT IN SCIENCE IN THE ELEMENTARY SCHOOL IN ISRAEL

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ABSTRACT

The purpose of the study was to: (a) examine the state of elementary science education in Israel and the achievement of students at the end of elementary school, (b) clarify and measure the effect of school variables on achievement in science.

The present study relates to previous studies on achievement at the elementary school in Israel. From a broader perspective it can also be considered as a contribution to the vast body of research on school effectiveness, and as such, it is part of the IEA study on science teaching conducted last year in 26 countries.

A stratified sample of 96 schools, countrywide, was selected. Six different questionnaires and three tests were administered to students, teachers and principals. The information gathered revealed a situation of quite a satisfactory state of science teaching conditions in Israel. However, the achievement of one-third of the population was found to be rather low. In an attempt to determine the impact of different school variables on the variance of science achievement, the contribution of many school factors (both physical inputs as well as sociopsychological and process variables) was analyzed. The level of exposure to the formal curriculum in school was found to be one of the most influential of these factors.

Session A-4

THE ROLE OF COGNITIVE FACTORS IN CHEMISTRY ACHIEVEMENT

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ABSTRACT

The grade 11 and 12 chemistry course in Western Australia is generally considered to be conceptually demanding. The first year of this course assumes a considerable knowledge of a number of concepts, facts and principles in chemistry. Research evidence indicates that cognitive factors such as prior knowledge, formal reasoning ability, intelligence, disembedding ability and memory capacity are significantly related to science achievement. This study investigated possible relationships among these cognitive variables and chemistry achievement. The data for the investigation were collected from grade 11 chemistry students in 11 high schools in the metropolitan area of Perth, Australia.

The results of the study indicated that prior knowledge and formal reasoning ability were the best predictors of chemistry achievement, laboratory application skills and problem solving ability. A path analysis provided support for causal hypotheses linking laboratory application skills and problem solving ability with understanding of concepts, facts and principles of chemistry.

The findings of this investigation have implications for curriculum development and implementation and for teacher education programs involving high school chemistry.

Session A-4

PREDICTING CONTINUED PARTICIPATION IN COLLEGE CHEMISTRY FOR MEN AND WOMEN

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ABSTRACT

The purpose of this study was to test the effectiveness of a cognitive motivational model of course selection patterns to explain the continued participation of men and women in college science courses. A number of cognitive motivational constructs was analyzed in a path model and their effect on students' intention to continue in college chemistry was determined. Variables in the model included self-concept of ability, future expectations, level of past success, effort expended, subjective interpretations of both past success and task difficulty, and intended persistence, the dependent variable in the model. The data were also examined for sex differences in the plan to continue in chemistry that might be explained by the elements of the model.

The results showed no sex differences in course performance, the plan to continue in chemistry, self-concept of ability, or past achievement in science courses. The path analysis did confirm, however, the usefulness of the cognitive motivational perspective to explain the intention of both men and women to continue in science. (The model explained 35% of the variance in the students' plan to take additional chemistry.) Central to that process appears to be a person's self-concept of ability. Students who had confidence in their ability in chemistry expected to do well in the future and were more likely to plan to take more chemistry. Self-concept of ability in turn was dependent on a number of past achievement experiences and the personal interpretations of those experiences.

Session A-4

THE EFFECTS OF COPING STRATEGIES UPON SCIENCE ACHIEVEMENT OF COMMUNITY COLLEGE STUDENTS

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ABSTRACT

How people view the world around them has a tremendous impact on their actions and affects the choices that they make. Field independence and field dependence have been shown to affect a person's perception. It has further been shown to have some impact on the science achievement of students.

Some teaching strategies have been studied and tested to see if they could improve the performance of field dependent students. The successful ones always included experiences for students that involved both the correct and incorrect responses. This study assesses the effectiveness of coping strategies designed to increase the science achievement of field dependent students. These strategies were integrated into a geology course designed for nonscience majors. Preliminary results indicate that they were successful. Further results and implications will be discussed during the presentation.

Session A-5

NEUROSCIENCE, COGNITIVE SCIENCE AND SCIENCE EDUCATION -- BI-COASTAL PERSPECTIVES

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ABSTRACT

There exists a high level of concern among science education leadership about how people learn science. Mechanisms for learning and memory in general have been proposed by researchers in a number of fields, among which are cognitive science and neuroscience. Basic questions about learning can be answered more completely through interdisciplinary efforts. Indeed, these efforts are mutually beneficial for all participants, as is evident from the success of interdisciplinary groups on two sides of the country.

The two presenters will welcome dialogue with the audience as they address:

1. What is happening in their respective areas related to neuroscience, cognitive science and science education.
2. Conceptual models which hold promise for science education research.
3. Questions and implications for science educators.

ASSESSMENT OF APTITUDE INTERACTIONS FOR THE MOST COMMON SCIENCE INSTRUCTIONAL STRATEGIES

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ABSTRACT

Many educational researchers neglect the aptitudes of the learners when they assess the relative effectiveness of instructional ploys. Critics of this approach question whether any strategy is best for learners of all aptitudes. The likely sitation, as they see it, is that a successful strategy for learners possessing comparable characteristics may be inadequate for learners having differing aptitude traits. Research that probes the interaction of aptitudes with varying instructional strategies is termed A-T-I (Aptitude-Treatment-Interaction). It was the purpose of this study to examine A-T-I's for the two most widely used science teaching strategies (i.e., lecture and lecture augmented with classroom activities). Two aptitude variables were examined: cognitive ability level expressed in Piagetian terms and cognitive learning style (field dependence/independence). A sample of 200 high school biology students (100 for each treatment group) was utilized. Each treatment group was stratified for cognitive ability level. Achievement was measured in a criterion-referenced fashion (mastery vs. nonmastery of eight biology concepts). The findings were that both aptitude variables interacted with achievement, and that the two treatments differed only marginally in the A-T-I. Of the two aptitudes analyzed, cognitive ability level had the greater interaction--i.e., higher cognition favored mastery, while lower cognition did not. A strong correlation (zero-order gamma of .53 for each biology concept studied) was found between cognitive ability level and cognitive learning style. Being field independent and of a higher cognitive ability level was more indicative of achievement than being field dependent and of a higher cognitive ability level. Students of lower ability levels were more often field dependent and mastered the biology concept infrequently.

Session A-7

THE ATTAINMENT OF SCIENTIFIC LITERACY BY URBAN HIGH SCHOOL SENIORS

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ABSTRACT

Data collected from a representative sample of urban high school seniors were subjected to path analysis to test the consequences of a priori causal assumptions about the scientific literacy attainment process. The hypothetical model consisted of eight variable levels. The dependent variable was measured with a seven dimension scientific literacy instrument. Race, gender, IQ, and SES were treated as exogenous variables. The intervening levels were (in order): early achievement, influences of significant others, fate control, motivation, and quantity of instruction. Causal relationships between an additional exogenous variable (quality of instruction) and fate control, motivation, and scientific literacy were also hypothesized.

Race, gender, and measures of SES, aptitude, reading achievement, peer encouragement and evaluation, teacher encouragements to take more science courses and to do well in science, parental encouragement and evaluation, fate control in science, science self-concept, vocational-educational expectations, amount of in-school and outside-of-school science instruction, and quality of high school science instruction were all found to contribute meaningfully to outcome. Achievement motivation (importance of grades, competition, and mastery) and junior high school science performance/feedback in the form of grades were found not to be meaningful predictors for the total sample. The effect of outside-of-school learning was found to be three times that of the in-school contribution.

Compared to males and non-blacks, females and blacks were found to be less literate. The causal assumptions explained a large portion of the gender difference and a much smaller portion of the race difference. In general, female attainment was found to be much more dependent on the support of significant others, vocational-educational expectations, science self-concept, fate control, math achievement, and classroom psychological comfort. Science achievement motivation had a negative effect on female performance and positive effect on male performance. Performance of black students was found to be more dependent on in-school

instruction and associated encouragements, and the quality of science instruction.

Problems were encountered in measuring the influences of significant others and motivational levels of black students, resulting in conservative estimates of the effects of these variables for the total group and for the black subgroup. The model accounted for 53% of the variance for blacks, 58% for whites, 55% for females, and 67% for males.

Session A-7

EDUCATIONAL PRODUCTIVITY IN SCIENCE EDUCATION: SECONDARY ANALYSIS OF NATIONAL ASSESSMENT IN SCIENCE DATA

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ABSTRACT

According to Walberg's theory of educational productivity, the following nine factors require optimization to increase student achievement of cognitive and affective outcomes: ability, age, motivation, quantity of instruction, quality of instruction, home environment, class environment, peer group environment, and mass media. These nine factors were identified from a synthesis of about 3,000 individual studies of factors related to learning.

Most individual experiments or quasi-experiments analyze only one or two factors and involve samples which are of limited size and are not national. Survey research can complement experimental studies because it often draws large, stratified, random samples from national populations and because it often involves numerous predictors of learning. The National Assessment in Science is an example of a survey which included items which could be interpreted as measures of most of the factors in Walberg's model. Consequently, secondary analyses were conducted for the purpose of probing the validity of the model.

The first step involved operationalizing two measures of student outcomes, namely, achievement and attitude. The next step involved operationalizing measures of 7 of the 9 productivity factors: ability, motivation, quality of instruction (indexed by the science teaching budget), quantity of instruction (minutes of science per week and amount of homework), home environment, class environment, and media (amount of television viewing). Also the two additional variables of gender and race were included because of their strong relationship with student outcomes in past research.

The National Assessment in Science involved a national random sample of 18,000 students aged 9, 13, and 17 in about 700 schools. But the present productivity analyses were restricted to the group of 1,960 nine year-olds who had completed all test items which made up the variables in the productivity model. The set of 10 predictors was regressed separately on achievement and attitude using a "backwards elimination" multiple regression method in which variables were dropped progressively from the equation until all remaining predictors had regression coefficients which were significantly different from zero.

When controlled for other factors, ability, motivation, class environment, home environment, amount of television viewing, gender and race were all found to be significantly related to cognitive achievement. For the attitude outcome, the variables linked with attitude were ability, motivation, class environment and race. These results for nine-year olds are compared with those from analogous secondary analyses of National Assessment in Science data for 13- and 17-year olds. Overall, the findings add support for the model of educational productivity and suggest that science students' achievements and attitude are jointly influenced by a number of factors rather than one of two dominant ones.

Session A-9

RESEARCH INTERESTS OF SECONDARY SCIENCE TEACHERS

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ABSTRACT

In the past few years science educators and the nation at large have become increasingly concerned about the "Crisis in Science Education." An underlying cause of this crisis is the nonuniform quality of instruction delivered by secondary science teachers. One way to improve the quality of teaching in the schools is the application of science education research findings to teaching. Most teachers are unaware of the research findings and/or do not apply them in their classrooms. This study helps determine the areas of research which are of greatest interest to secondary science teachers. Results will be used by NSTA to determine the contents of future volumes of the monograph What Research Says to the Science Teacher.

A random sample of 600 secondary science teachers was obtained from the National Registry of NSTA. Teachers were sent a 23 item questionnaire that asked them to rate their interest in each research topic on a five point scale. The questionnaire contained the 12 items prepared by a NARST-NSTA committee in 1979, and an additional 11 items using the same format. Demographic data collected from the survey included sex, teaching assignment, role and familiarity with What Research Says.... Data were analyzed using these demographic data as well as according to whether teachers returned the original or a follow-up questionnaire. Sixty percent of the teachers completed the

questionnaire in usable form. Overall results of the study, based on both frequency of response and on mean rating, indicate that the following five topics are of greatest interest to secondary science teachers: laboratory experiences, motivational techniques, effect on college courses, problem solving, and meaningful learning. Analysis of data according to the subject taught indicated that chemistry and physics teachers are more interested in problem solving than are biology teachers, and that chemistry, physics, and earth science teachers are also interested in the sequence of the content. Males and females had the same top five interests but in a different order. The same is true for teachers of grades 7-9 versus grades 10-12. Rural teachers' preferences varied substantially from those in other settings, and differences were also found for teachers' familiary with What Research Says... compared to the rest of the sample. Teachers who returned the first questionnaire had basically the same preferences as those who returned the follow-up questionnaire. For every classification of teacher, the area of least interest was sex difference research.

Session A-10

EFFECTS OF TEACHERS' USE OF CONCRETE ANALOGIES ON ACHIEVEMENT OF HIGH SCHOOL BIOLOGY STUDENTS WITH VARYING LEVELS OF PRIOR KNOWLEDGE AND COGNITIVE ABILITY

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ABSTRACT

The purpose of this study was to compare the effects of analogy-based and conventional lecture-based instructional strategies on biology achievement of students enrolled in four classes at a suburban high school. Prior to treatment, students were assessed for cognitive ability and prior knowledge. A numeric grade from the previous term of biology served as a covariate. The study was conducted over three units of instruction.

The analogy-based treatment consisted of teacher lecture and student examination of analogy text, diagrams and charts comparing target information to an analogous domain. Conventional lecture-based strategies involved didactic teacher presentation of target concepts supplemented with reading assignments from the regular classroom text. Instruction for each unit lasted two days, followed by an achievement measure every third day.

Analysis of covariance procedures were used to identify main effects on achievement related to treatment, cognitive ability and prior knowledge. Interactions between variables were assessed by the same procedures. Data concerning comprehension of the analogies were also analyzed with respect to possible effects on achievement.

Conclusions drawn from evidence in this study suggest:

1. Analogy-based instructional methods appear to enhance student performance relative to conventional lecture-based instruction in achievement related to the digestive, nervous and circulatory systems.

2. Both concrete and transitional/formal operational students benefited from analogy-based instruction.

3. With both treatments, transitional/formal operational students tended to show higher achievement than concrete operational students.

4. Concrete operational students receiving analogy-based instruction scored higher than transitional/formal operational students receiving conventional lecture-based instruction.

5. Students who comprehended analogies showed significantly higher achievement over those who did not comprehend them.

6. The effects related to treatment tended to be more pronounced when comprehension of the analogy was high.

Session A-10

ATTITUDE AND ACHIEVEMENT IN NINTH GRADE PHYSICAL SCIENCE OF LOW NEED LEVEL STUDENTS: A REEXAMINATION OF THE MATCHING HYPOTHESIS

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ABSTRACT

In a previous study, the benefits of matching instruction with the students' needs were examined. Three personality variables were used for the purpose of matching: Maslowian need level, locus of control, and cognitive style. Participants in the study were students (n=301) enrolled in ninth grade physical science and their teachers (n=4) in one high school in the central Texas region. Instruction was designed to accommodate, to differing extents, the needs for love and belonging, an external locus of control, and a field dependent cognitive style. Cognitive and affective outcomes served as the dependent variables for the study, which lasted for 21 class days. Results of the study indicated that 55% of the sample, 166 students, registered physiological and safety as their primary needs; data for these students were excluded from the study. For the remainder of the sample, the benefits of matching proved to be inconsistent. As the degree of compatibility increased, students' attitudes toward science in general improved. Neither achievement nor attitude toward physical science class, the physical science teacher, or the method of instruction improved as a result of matching.

The present study examined the cognitive and affective entry characteristics of the ninth grade physical science students participating in the previous investigation and the benefits of matching for students possessing low level needs. Significant differences were found in the cognitive and affective entry characteristics of students of differing need levels. Students differed in their attitudes toward science in general ($p < .01$) and their prior knowledge of physical science ($p < .05$). Matching did not prove to be beneficial for students primarily concerned with the fulfillment of low level needs, i.e., physiological and safety needs. Differences in achievement, not attitude, were found ($p < .01$) to be dependent upon the extent of matching.

Unexpected, however, was the finding that increased compatibility (i.e., more complete matching) resulted in lower achievement.

The results of the study are discussed in terms of the matching model of instruction and the desire to design instruction to accommodate the diversity of student needs in introductory, secondary school physical science courses.

Session A-10

RELATIONSHIPS BETWEEN SUBJECT PREFERENCE, GENDER, AND ATTITUDE TOWARD SCIENCE

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ABSTRACT

Several factors such as self concept, classroom environment, family background, and gender have been shown to be related to student attitudes toward science. This study examined the relationship of student's favorite subject with attitude toward science. Specifically, it was designed to determine if students with different favorite subjects possessed different attitudes toward science and the effect, if any, that student gender had on this relationship.

Data were collected from 4500 sixth through tenth grade students enrolled in a school district in North Carolina. An attitude instrument assessed student attitude toward science. Students selected their favorite subject from four; English, mathematics, science, and social studies.

There were significant differences in attitudes toward science among students having different favorite subjects. Students choosing science as their favorite subject had the most positive attitude toward science, while students that preferred English had the least positive attitude toward science. There were no significant differences in the findings due to gender. Both males and females showed the same pattern of relationships between favorite subject and attitude toward science found in the entire population. It would appear that gender does not play an important role in the relationship between favorite subject and attitude toward science.

Session A-11

THE IDENTIFICATION, DEFINITION AND MEASUREMENT OF KEY VARIABLES IN WAIT TIME RESEARCH

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ABSTRACT

The purpose of this paper is to examine the problems involved in the identification, definition, and measurement of those critical variables in the classroom that relate to the effectiveness of teaching and learning.

We will address three points relevant to classroom interaction analysis:

1. Discussion classification. Few researchers have attempted to conceptualize the nature of the discussion in classrooms. A new category system, based on the series of definitions is presented as a basis for further development.

2. Wait time. A variety of terms have been used to describe the multiple types of pauses that may be encountered in the analysis of classroom dialogues. These and other types of interactive pauses are examined.

Electronic feedback devices, called Wait Timers, have been demonstrated to assist teacher and students to successfully extend their wait times. The relative significance of wait times 1 and 2 is evaluated.

3. Other variables. There are numerous variables, in addition to wait time, that may be measured in classroom interaction. These include: cognitive levels of teacher statements or questions, student cognitive levels, ratio of teacher and student talk, affective climate measures, achievement measures, patterns of interaction, non-verbal cues, and alternatives to questions. The effectiveness of these variables will be compared with reference to their ability to parsimoniously describe the essential characteristics of classrooms. Examples are drawn from our work and the work of others.

Session A-11

WAIT TIME IN SCIENCE: NECESSARY BUT NOT SUFFICIENT

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ABSTRACT

It is important to examine the use of extended wait time in whole class settings because this mode of teaching appears to predominate in American and Australian science classes. However, recent research raises questions about the probable beneficiaries of an extended wait time in whole class settings. Teachers tend to interact with a relatively small group of target students when questions are asked to stimulate thinking or to obtain student responses that can be used as a bridge to new content. Target students appear to be those that can be relied upon to provide a response that the teacher can use in subsequent instruction. If other students do listen to these responses then it can be argued that extension of wait time is generally beneficial. However, if students do not carefully attend to the content of peer responses then an extended wait time might benefit target students to a much greater extent than it would non-target students.

An assumption that underlies the use of an extended wait time in whole class interactive settings is that additional time can be used by teachers and students for cognitive processing. This may not always be necessary. In an experimental setting lesson plans are often provided in order to control for unwanted variance in the implemented curriculum in different classes. By so doing, the activities in which students are to engage are specified. As a consequence, an implemented science curriculum usually provides opportunities for students to engage in higher cognitive level tasks. In a non-experimental situation engagement patterns are often quite different. The evaluation system tends to shape the implemented curriculum in most Australian schools. Teachers plan and implement activities to enable students to pass the examinations and tests or to attain a high course grade. As a consequence, many of the interactions that occur are pitched at a low cognitive level. Algorithms are introduced and learned in order to allow students to get the right answers. The use of algorithms tends to reduce the cognitive demands of the work to be done. As a consequence, when teachers implement the regular science curriculum, the cognitive level of whole class interactions is often low. There are numerous instances in each lesson when there is not much to be gained by pausing for 3 to 5 seconds. Unless the implemented curriculum requires students to think, there is little value in providing them with time to think. The introduction of an extended wait time alone may not produce

the improvements that research on wait time suggests. Unless the implemented curriculum is providing students with opportunities to develop higher cognitive level outcomes, there is little point in using an extended wait time.

The symposium presentation will review the results of a ten year program of research on teacher wait time and will synthesize these results with those of an ethnographic study of high school science. Implications of the research will be presented for further research, teacher education, curriculum design and classroom practice.

Session A-11

ACQUISITION OF WAIT TIME; TRAINING TECHNIQUES AND RELATED TEACHER BEHAVIORS: THE WAIT TIMER AND SUPPORTIVE INTERVENTION

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ABSTRACT

Since the initial studies of wait time/inquiry twenty years ago, progress has been made to implement the studies of Rowe, DeTure, Swift and Gooding, and Tobin and Capie. One approach utilizes a device that flashes a light indicating when 3 seconds have elapsed after a person stops speaking. This is an unobtrusive indication of wait time, and while it may seem to be a simple solution, it allows both students and teachers to learn to pause for thinking time. Previous attempts to train teachers in wait time were costly in time and effort. This new "Wait Timer" device has proven to be successful in training teachers to pause without the intrusive appearance of a researcher or teacher trainer. An added benefit occurred when students also began to wait. Even the brighter students began to realize that if they paused to think, they could compose better answers.

The effect of using the Wait Timer was enhanced when tape recordings of classroom discussions were analyzed by a research staff. Reports to the teachers in the following week emphasized only positive teaching behaviors. This process, termed "supportive intervention," resulted in longer wait times by teachers and students, higher cognitive questioning levels by teachers, more student-student interaction, fewer disciplinary remarks, fewer classroom management actions, and more enthusiastic teachers.

The results of this study indicate that the use of the electronic device coupled with supportive intervention can effectively improve classroom interaction between students and teachers.

Session A-11

ACQUISITION OF WAIT TIME; TRAINING TECHNIQUES AND RELATED TEACHER BEHAVIORS: MODELING PROTOCOLS

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ABSTRACT

A major concern associated with wait time research is developing an expedient process for training teachers to effectively engage in criterion wait time. The consensus of the research is that if teachers use 3 plus seconds during discussion many positive behavior changes occur in both teacher and student outcome variables. However, having teachers internalize and value the proposed pausing patterns goes beyond simple training.

Developing effective training techniques has been a necessary focus of a number of research projects. Two successful approaches have involved either the principles of observational learning via modeling or the advent of a mechanical device that gives continuous feedback to the participants. Training is the initial step in implementing wait time into classroom practice. It appears that follow up support is necessary for what may be a critical period when the teacher begins to adopt extended wait time as an effective teaching strategy. Studies with preservice and inservice teachers support this notion.

The purpose of this paper is to explore the research related to training and to examine strategies that will enable teachers to utilize wait time as an ongoing practice.

Session A-12

CONCEPT MAPPING: A LEARNING STRATEGY FROM RESEARCH PUT INTO PRACTICE

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ABSTRACT

Since 1975, the Cornell University Science Education program has employed concept mapping in most of the research studies. Since 1980, concept mapping has been used in innovative teaching programs in the northwest suburban Chicago area, as well as in the inner city of Gary, Indiana. We have found that students from grade one through graduate school benefit from constructing concept maps in that the maps teach them to identify and relate key concepts and propositions in materials they are studying. Also, concept mapping helps students to "learn how to learn." This strategy is meaningful for teachers in the organization of their teaching presentation as well as in the evaluation of misconceptions in their students. In this workshop, several illustrative concept maps will be presented along with a brief introduction to the psychological principles underlying concept maps. A simple concept map will be constructed from a short text, and from a list of related concept words. Participants will construct a simple concept map. Computer programs recently developed on concept mapping will be available. Examples of procedures to teach 'concept mapping' to students will be provided. Participants should be ready to understand research relevant to education issues suggested by concept mapping strategies.

Session A-12

COMPUTER INSTRUCTED AND COMPUTER FACILITATED CONCEPT MAPPING

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ABSTRACT

Educational research has established that concept mapping, CM, is a technique that facilitates "meaningful" learning. However, teachers have not made a commitment to use this learning tool. It would appear that teachers are reluctant to commit class time to the teaching and evaluation of CM at the expense of time previously allocated to course content areas. The only solution to this dilemma comes about if we can become so efficient at teaching and evaluating CM that in-class time used for this purpose is minimized.

For this reason the Apple computer is the key to the success of our proposed program. It can provide out-of-class tutorial instruction in CM which will be personal, convenient and repetitive. It will provide sufficient structure to allow efficient in-class evaluation of CM by both teachers and students.

Therefore, it is the goal of this study to instruct 6-10 chemistry teachers and 500 students enrolled in junior chemistry in how to concept map chemistry assignments using only one day of in-class time and computer aided instruction, CAI. An interactive computer tutorial and audiovisual aids have been created for this purpose.

A second and equally important goal of this study is to demonstrate that microcomputers can be used by faculty and students to create concept maps. Students and teachers will realize that computer generated concept mapping allows uniformity, flexibility, and storage which are impossible to achieve by paper and pencil methods.

Session A-12

CONSTRUCTING VEE MAPS FOR CLINICAL INTERVIEWS ON ENERGY CONCEPTS

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ABSTRACT

The purpose of this study was to apply the "Knowledge Vee" to the task of interpreting and representing children's energy conceptions as expressed during clinical interviews. Vee analyses were conducted on five transcripts covering the two year interval from sixth to eighth grade for three students.

Children resisted interpreting events in terms of meanings which challenged the relationships among highest level concepts. They clearly derived their grade eight level of understanding from concepts present in grade six. Those with "rich" conceptualization improved in understanding the most.

The Vees for energy concepts highlighted a tendency to misconstrue meaning in a manner consistent with everyday observation: energy is fuel-like and gets used up. Energy-being-used-up hinders progress in grasping the law of conservation of energy. The missing (yet learnable) proposition in children's knowledge seems to be that all the energy that made a change occur still exists, only in changed form, afterwards. Children appear to resist labeling many events examples of energy perhaps because they harbor the "source of fuel" image of energy.

In summary, the Interview Vee captures steps in the evolution of an individual's understanding and amplifies persistent, idiosyncratic patterns in personally grasped meanings. The products of Vee analysis support the utility of an Ausubelian explanatory framework.

Session A-13

EVIDENCE THAT SCIENCE LOCUS OF CONTROL ORIENTATION CAN BE MODIFIED THROUGH INSTRUCTION

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ABSTRACT

A desire to foster enduring, positive attitudes toward science teaching among elementary school teachers led to study of locus of control orientation as a contributor to attitudes. On the basis of evidence for a strong, positive relationship between internality and positive attitudes toward science teaching, it was decided to explore the possibility of fostering internality through instruction. Studied, then, was the effect of a required science methods course on the science locus of control (SciLOC) orientations of preservice elementary teachers.

A quasi-experimental research strategy was employed to study the effects of two instructional treatments. The strategy comprised a nonequivalent control group design, pretest measures to demonstrate the essential equivalence of treatment groups, and analysis of covariance (ANCOVA) techniques to test treatment effects. Both treatments incorporated strategies shown by research findings to have positive effects on the attitudes of subjects, but the novel treatment emphasized self-management, goal clarification, and individualized course expectations. The comparison treatment was more conventional in emphasizing academic achievement and the completion of a standard set of course requirements.

At the conclusion of treatment, the two subject groups were compared in terms of SciLOC orientation. There was found by ANCOVA to be a statistically significant ($p \leq .05$) difference between groups, with subjects exposed to the novel treatment exhibiting greater internality. The quantitative comprehension and age of subjects were used as covariates of SciLOC orientation, and subject gender was employed as a moderator variable. Though the treatment effect is small, accounting for 3% of the variance in SciLOC orientation, the finding seems to have educational significance. The demonstration that SciLOC internality can be enhanced through implementation of some rather passive instructional techniques over a 10-week period seems significant as a demonstration of potential, potential to be realized through further research. These results encourage attention to teacher attitudes from a rather new perspective, and they raise several

interesting research questions related to instructional methods and the long term effects of enhancing internality.

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Session A-13

THE ROLE OF THE SCIENCE TEXTBOOK IN A CONCEPTUAL CHANGE MODEL OF INSTRUCTION

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ABSTRACT

The paper draws on previously published work and two studies recently completed by the author to develop a theoretical position concerning the role that science textbooks can and should play in classroom teaching for conceptual change. One of the studies reported compared student processing and comprehension of a text designed to promote conceptual change with student processing and comprehension of two traditional texts. The other study investigated the effects of the experimental text on teacher behavior and student learning in a classroom where an activity-based program was in use. In both studies, students using the experimental text were much more successful in relinquishing their misconceptions in favor of scientific understandings about photosynthesis and food for plants than students using the traditional texts or than students receiving activity-based instruction. Features of the text and of its successful use in the classroom are contrasted with features of traditional texts and traditional textbook instruction. The argument is developed that, while traditional texts prove more often to be obstacles to student learning rather than aids, a text can be a useful tool in conceptual change teaching if the textbook is sensitive to students' misconceptions. It is proposed that a new kind of textbook development based on knowledge about students' misconceptions is needed.

Session A-13

EFFECT OF PRETEST CLINICAL INTERVIEWS ON POSTTEST CLINICAL INTERVIEWS FOLLOWING INSTRUCTION

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ABSTRACT

Recent theories in cognitive psychology suggest that what students learn from instruction is a result of the interaction of their prior knowledge and instructional content. As a result, researchers in science education are viewing learning as the changes in knowledge that result from instruction. The assessment of knowledge changes is often being done by the use of pre-instruction and post-instruction clinical interviews. There is, however, a potential problem in the use of clinical interviews in this manner. The initial clinical interview may alter what students learn from the instruction, thus changing their responses during the subsequent interviews.

The purpose of this study was to determine the effects of pre-instruction clinical interviews on post-instruction interviews. Twenty four students were randomly selected from eleventh grade chemistry classes and randomly assigned to either an experimental or a control group. The experimental group was given a pre-instruction interview, instruction in the form of a reading passage about thermal energy transfer, and a post-instruction interview. The control group read the passage and participated in the subsequent interview. There was one week between the first interview and instruction and one week between the instruction and second interview. During the interview, students were presented with an activity in which thermal energy transfer occurred. They were asked to predict, describe and explain the event. In addition, the interviewer asked questions requiring students to clarify the concepts they used.

The interviews were tape recorded, transcribed and analyzed to determine the propositions students used to describe and explain the event. The meaning of each related concepts such as heat, water, or molecular collisions. The performance of the groups was compared in terms of the numbers of correct propositions and numbers of incorrect or ambiguous propositions they used. A similar comparison was made using only propositions in which concepts directly related to the reading were used. No comparison indicated a statistically significant difference. However, the experimental group used a substantially smaller

percentage of incorrect or ambiguous propositions in both comparisons. A qualitative analysis of these differences indicated the decrease in incorrect and ambiguous propositions resulted in a more coherent and understandable posttest interview for those in the experimental group. The qualitative analysis also indicated that four of the twelve students in the experimental group correctly related thermal energy transfer to molecular collisions and changes in molecular motion. This was the major theme of the passage. Only one student in the control group expressed this complete set of propositions during the posttest.

The conclusion was that the initial clinical interview did not result in extreme post-instruction interview differences. However, enough students in the control group learned sufficiently more coherent and complete knowledge about thermal energy transfer to be of concern. Additional studies of this problem in other content domains with larger n's are needed.

Session A-14

BIOLOGY INSTRUCTION BY INTERACTIVE VIDEODISC OR CONVENTIONAL LABORATORY: A QUALITATIVE COMPARISON

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ABSTRACT

This study was designed to learn if students perceived an interactive computer/videodisc learning system to represent a viable alternative to (or extension of) the conventional laboratory for learning biology skills and concepts normally taught under classroom laboratory conditions. Data were collected by questionnaire in introductory biology classes of three categorically different postsecondary institutions where students used an interactive videodisc/computer lesson on respiration and biogeography instead of the traditional laboratory investigation. The system consisted of a TRS-80 Model III microcomputer interfaced to a Pioneer laser disc player and a color TV monitor.

Students indicated a comparatively high level of satisfaction with this strategy and responded consistently favorably to the aspect of efficiency of instructional time. These two generalizations are consistent with past CAI research. Students found the two approaches to be equivalent to conventional laboratory instruction in the areas of general interest, understanding of basic principles, help on examinations, and attitude toward science. Students also had a strong perception that the images on the videodisc "were not real" and this factor presented perceived both advantages and disadvantages. It is inferred that the videodisc/computer technology will not likely serve as a viable substitute to the "wet" laboratory experience, but that this medium may substantially enrich the spectrum of educational experiences usually not possible in typical classroom settings.

Session A-14

INTERACTIVE COMPUTER/VIDEODISC LESSONS AND THEIR EFFECT ON STUDENTS' UNDERSTANDING OF SCIENCE

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ABSTRACT

The purpose of this research was the comparison of interactive videodisc instruction with standard laboratory instruction in a college level physics course. Forty-nine students enrolled in physics at George Mason University took part in the study. Twenty-two students formed the experimental group and performed the interactive videodisc laboratory "The Puzzle of the Tacoma Narrows Bridge Collapse." The videodisc laboratory was enhanced by the investigator to make it a computer controlled, Level Three Videodisc Lesson. Twenty-seven students formed the control group and performed a traditional laboratory on the physics of standing waves on strings. The criterion instruments were an investigator-constructed content pre and post-test, the Schwirian Science Support Scale forms A and B, subjects' Laboratory Data Tables, and Computer Recorded Data Tables. Using analysis of covariance, no statistically significant difference was found in the performance of the two groups on the Physics Content test. An analysis of variance on the Laboratory Data Tables and the Computer Recorded Data Tables showed that the two groups separated and controlled variables in significantly ($p < .001$) different ways. A chi-square test ($p < .0005$) on the Computer Recorded Data Tables showed the students in the experimental group were selecting variables in terms of symmetric patterns on the video monitor rather than separating and controlling the variables of the videodisc laboratory. Data are presented that indicate the success of the traditional laboratory group in the task of separation and control of variables was due primarily to the physical nature of the equipment, not to their ability to separate and control variables.

Session A-14

EFFECTS OF MICROCOMPUTER SIMULATIONS ON ACHIEVEMENT AND ATTITUDES OF MIDDLE SCHOOL STUDENTS

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ABSTRACT

The purpose of this study was to compare the effects of alternative ways of using microcomputer simulations on achievement and attitudes of middle school students. The instructional strategies compared were microcomputer simulations, laboratory activities, a combination of the two, and conventional classroom instruction. The measured attitudes were toward computers and science instruction.

Specific questions addressed in this study were:

1. Do differences in achievement and attitudes exist among middle school students receiving instruction using computer simulations?

2. Do differences in achievement and attitude exist among students with different levels of logical reasoning ability?

3. Are the effects of instruction using microcomputer simulations on achievement and attitude consistent across levels of logical reasoning ability?

Outcome data were collected from nine classes of sixth and seventh grade science students (n = 173). Each class was randomly assigned to one of the instructional strategies. Topics covered in this study included the process skills of observing, hypothesizing, testing, classifying, and recording data. The simulations and laboratory activities were keyed to instructional objectives which all students were working to achieve. The students worked on the simulations as a class with the teacher operating the microcomputer and simulation programs. The students worked in groups of two or three during laboratory activities. The simulations were presented prior to the activity in the combination treatment. The study lasted ten days.

The following answers to the research questions appear to be tenable based on achievement and attitude data collected during the investigation:

1. Microcomputer simulations, laboratory activities, and a combination of the two instructional strategies resulted in higher achievement than conventional classroom instruction. Neither achievement nor attitude differences were found among the three treatment groups receiving computer simulations, laboratory activities, or a combination of the two. No differences in attitudes were found among any of the four groups.

2. Students at the high and middle levels of logical reasoning ability out-achieve students at the low level of logical reasoning ability. No significant differences in attitudes among the three groups were found.

3. The effects of the alternative instructional strategies were consistent across levels of logical reasoning ability.

Session A-15

UNANSWERED QUESTIONS RELATED TO PROBLEM SOLVING IN CHEMISTRY

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ABSTRACT

Previous papers in this paper set describe the role of spatial ability in solving problems in chemistry, a comparison of experts and novices in solving stoichiometry problems in chemistry, and research related to a teaching strategy for improving problem solving in chemistry. This final paper in the set describes where we are in our understanding of problem solving in chemistry and what questions must be addressed before we can make firm recommendations for changing chemistry instruction to enhance problem solving ability.

Research by Nurrenbern, Gabel, Ward, Cantu, Greenbowe, and Gilbert in this country as well as research by Johnstone in Scotland, Frazier in England and Ben-Zvi, Silverman and Eylon in Israel make clear that poor performance by chemistry students on complex intellectual tasks may be attributed to many factors:

1. Students fail to solve problems because they quit.

2. Students fail because they do not understand what the problem says.

3. Students fail because they misread the problem , make incorrect inferences, make computational errors, quit before reaching the solution called for, or otherwise misapply the skills and information that they are capable of bringing to bear.

4. Students fail because they lack (or fail to recall) information needed to solve the problem.

5. Students fail because they do not represent the problem in a suitable problem space.

6. Students fail because they are unable to generate a solution path within the problem space.

7. Students fail because they lose track of where they are along the solution path.

Other causes of failure could be added to this list, but the point is that we now have a great deal of information concerning the various impediments to problem solving success. Before this knowledge can be translated into practical suggestions for instructional improvement, much more research is needed. Among the questions that need attention are these:

1. We know that many students adopt inappropriate strategies for solving problems because of "misconceptions" concerning the nature of the physical world. For example, students' conceptions concerning the microscopic nature of matter are often very different from scientists' conceptions and those "misconceptions" lead students to perform "senseless" operations. What we do not know is just how prevalent such misconceptions are or how they can be easily detected and remediated during the course of instruction.

2. We know that the most common strategy used by beginning students in attacking problems such as those commonly encountered in texts is to instantiate a memorized rule or formula. We also know that such "blind" application of rules and formulas frequently leads to incorrect "solutions". However, it is also true that successful problem solvers make frequent use of the rules and formulas so frequently misapplied by poor problem solvers. We need to know more about when and how rules must be taught in order for them to be applied appropriately. For example, did expert problem solvers go through a stage in which they also misapplied the rules and formulas that they now use correctly? Is it necessary (or at least desirable) to bring students to a certain level of proficiency in applying rules in a more or less rote manner before we can reasonably expect them to address non-routine tasks successfully?

3. It is apparent that successful problem solvers utilize many strategies for verifying procedures that they are using to solve problems and that they apply these procedures routinely. They often seem to be unconscious that they are in fact checking on the validity of what they are doing. What we do not know is just how individuals went about developing these intellectual habits and to what extent they can be fostered by deliberate instruction.

4. It is also apparent that the procedure followed by "expert" problem solvers when they are solving novel problems are very different from textbook solutions that tell students how to go about solving problems. To what extent does such misrepresentation of the problem solving process deter the development of problem solving skills on the part of novices? If it impedes rather than enhances the development of problem solving skills as some of us suspect, what should be substituted for the kind of textbook solutions we now see?

Session A-15

THE EFFECT OF A PROBLEM-SOLVING METHOD ON PROBLEM-SOLVING PROCESSES

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ABSTRACT

A problem-solving method of teaching is being used in the recitation sections of a university-level freshman chemistry course for science and engineering majors. This method is based on prior results of research on problem solving by Greenbowe and Hurrenbern which revealed that good problem solvers formed better representations and used heuristics more often than poor problem solvers.

Briefly, the model for solving problems consists of three phases: (1) planning the solution, (2) solving the problem, and (3) reviewing the solution. The use of general problem solving strategies, or heuristics, is stressed throughout, as is the use of three different modes of representing the problem (the macroscopic level, the microscopic level, and the symbolic level).

A posttest-only control-group design is being used to experimentally test the model. Two instructors are each teaching a control section and an experimental section. Each section has 20 to 24 students. In the control section, the instructors are primarily going over the assigned problems for the week at the students' request. In the experimental section the instructors are using the problem-solving model for both students' questions and new problems in recitation.

After twelve weeks of instruction, students in the study will be given individual think-aloud interviews to judge their use of selected problem-solving processes.

Session A-15

THE ROLE OF SPATIAL ABILITY AND ACHIEVEMENT IN ORGANIC CHEMISTRY

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ABSTRACT

The purpose of this study was to investigate the role that spatial ability has in achievement in organic chemistry. Spatial ability for this study was defined as containing two subfactors: Spatial Visualization and Spatial Orientation. Spatial Visualization is the ability to mentally manipulate pictorially presented stimuli. Involved in the processes of manipulation are the abilities of recognition, retention, and recall of a configuration in which there is movement among the internal parts. Spatial Orientation is the ability to remain unconfused by changing orientations in which a configuration may be presented. Spatial Orientation was measured using the Purdue Visualization of Rotations Test and Spatial Visualization was measured using the Find a Shape Puzzle. Achievement was measured by students' exam scores in an organic chemistry course. The course used was CHEM 257, a course designed for nonscience majors, particularly for those students in agriculture and health sciences. Scores on the Scholastic Aptitude Test, SAT, were used as covariates.

Both the analysis of variance and the analysis of covariance suggest that there is a difference between the mean exam score for the spatial groups. For CHEM 257, the low spatial group scored significantly lower than the high spatial group on the organic exams.

Also looked at were the similarities and differences between the work of the high and the low spatial students. The high spatial students made more use of drawings than the low spatial students on questions that asked for drawings and also on questions that did not ask specifically for drawings. It was also found that students, regardless of spatial ability, who drew pictures scored higher on the exams.

Session A-15

SPATIAL ABILITY IN GENERAL CHEMISTRY

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ABSTRACT

This study examined the relationship between spatial skills and achievement in college general chemistry coursework. Preliminary work by McMillen and Bodner has shown significant correlations between level of spatial visualization and orientation ability and success in a chemistry course designed for science and engineering majors. The present study is an in-depth replication of McMillen's work with two groups of students (N approx. 1600) of science and engineering majors enrolled in a first semester general chemistry course. We also extended the study to a lower-level general chemistry course of about 800 students. This second course, designed for agriculture and nursing majors, was studied in order to determine whether spatial skills would be a more effective predictor of success in a chemistry course where lower levels of performance are expected, but also where student ability levels are generally lower. Sex differences in spatial ability and possible interactions between sex, spatial ability and chemistry achievement are also examined. Implications of the study for teaching science are discussed in relationship to recent data on the trainability of spatial skills.

Session A-15

COGNITIVE RESTRUCTURING AS A FIRST STEP IN PROBLEM SOLVING

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ABSTRACT

Chemists have bemoaned for years their students' inability to solve problems in introductory chemistry courses. However, at least part of this inability must be attributed to the fact that chemists have historically tried to teach their students to solve problems by doing nothing more than working examples.

In recent years, chemists have begun to realize the importance of general strategies or heuristics in problem solving, and they have become particularly enthralled with the "road map" approach to problem solving. There is abundant evidence, however, that students who understand the road map approach to problem solving all too often still cannot solve "simple" stoichiometry problems.

The hypothesis behind the research discussed in this paper is the assumption that there is a preliminary stage in problem solving which most chemists have neglected. During this preliminary stage, relevant information is disembedded and the problem is restructured. Until this stage is successfully completed, the student cannot proceed on to the analytic stage in which the road map heuristic can be applied.

Preliminary evidence supporting this hypothesis will be presented which suggests that there is a linear correlation between the students' ability to handle disembedding and cognitive restructuring tasks in the spatial domain and their ability to solve "simple" stoichiometry problems.

Session A-16

AN EXPLORATION OF ELEMENTARY STUDENTS' SCIENCE ACHIEVEMENT AS A FUNCTION OF LESSON STRUCTURE AND COGNITIVE STYLE

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ABSTRACT

Educators have constantly attempted to develop teaching strategies that complemented the learners' attributes to effectively achieve desired learning outcomes. Recent studies suggested that external lesson structure might compensate for the lack of internal learner structure. Two sources of external structure were considered, specifically teacher structure and content structure. Teacher structure was expressed by the degree of specific directions, instructions, procedures and organization. Content structure is expressed by the nature of the science topic being investigated, specifically descriptive science (biology) or prescriptive science (physics). Since content structure is rigidly connected to the science topic, it is difficult to simply explore the affect of content structure.

This study explored the effects of inquiry teaching/learning strategies varying in the degree of structure (a semi-deductive mode: content structure + low teacher structure and a teacher structured mode: content structure + high teacher structure) and students with different cognitive styles (field-dependent and field-independent) on the resulting science achievement (knowledge about magnetism, knowledge about chemical analysis and identification of chemical unknowns) of elementary school children. Two inquiry presentations were developed for two science topics; Magnets (EIS) and Myster Powders (ESS). One presentation mode encouraged relatively free exploration, while the second presentation mode provided a teacher-directed investigation. Cognitive style was assessed by the Group Embedded Figures Test (GEFT), which described the students' cognitive style, along a field-dependent/field-independent continuum. Science achievement was measured by teacher-made tests of knowledge and application.

Analysis of data indicated significant ($p \leq 0.05$) differences between cognitive styles favoring field-independent students and non-significant ($p > 0.05$) differences and

interactions for lesson-structure and cognitive style by lesson-structure.

Session A-16

RELATIONSHIP AMONG FORMAL REASONING SKILLS, GENDER, AGE, SCHOOL TYPE AND COGNITIVE LEARNING ABILITIES OF ISRAELI SECONDARY SCHOOL STUDENTS

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ABSTRACT

A Video-Taped Group Test (VTGT) of formal tasks was used in order to assess high school students' formal operational level and to find out if there are any relationships between students' tendency to study science subjects, their cognitive abilities and their performance on Piagetian-like formal tasks.

The sample consisted of 374 high school students from 7th to 11th grade, with an approximately equal number of boys and girls, from urban and rural schools.

The VTGT was content validated by science educators and high school science teachers who obtained an inter-judges' agreement of .93. In a pilot study with 300 students, the internal reliability analysis yielded a value of $\alpha = .83$. The mean score from a scale of 0 to 22 points maximum, on VTGT, was the dependent variable, and gender, age, school type, science subject preferences, and cognitive learning abilities served as categories for the independent variables.

The mean scores on the VTGT were statistically treated by a t-test, linear regression and three-way analysis of variance, by the categories mentioned above.

The results show that differences in VTGT achievements between boys and girls appear in the 7th and 8th grades and peak at a significant level in the 9th and 10th grades. It was also found that boys and girls use different cognitive abilities when performing the VTGT (girls tend to rely on verbal ability while boys relate more to spatial cues). Gender was found to have a main effect on the variance of the VTGT mean scores, even when the

differences on mathematical abilities were eliminated. While the gender-age interaction was found to have a significant effect, school type was not found to have any significant impact.

The findings of this study support the hypothesis that girls and boys, at a certain age or grade level, do not master formal operation skills to the same degree. Moreover, they tend to use different cognitive learning abilities in dealing with formal tasks. In addition, girls show a low preference rate for science in general. This information can help curriculum designers match the cognitive demands of the scientific concepts learned with the cognitive development and abilities of the students. In this way they can better meet the needs of both male and female students.

Session A-16

FACTORS INFLUENCING HIGH SCHOOL STUDENTS' SCIENCE ENROLLMENT PATTERNS: ACADEMIC ABILITIES, PARENTAL INFLUENCES, AND ATTITUDES TOWARD SCIENCE

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ABSTRACT

Using a path analytic model, this study was designed to assess the relative impact of different factors on science concentration decisions made by high school students. Included in the model were selected demographic and socioeconomic factors, academic abilities factors, indicators of home and school support, attitudes toward science, and students' science enrollment plans.

The subjects were 237 tenth grade students in two schools of a Midwest school system.

Two instruments were used to collect data related to the selected factors. School records were used to obtain math and science grades and the California Achievement Test scores from the previous school year. Descriptive, relational, model-fitting analyses were used. The results indicated that students, especially females and blacks, tended to avoid advanced and quantitative science courses. Student attitudes toward science were low, especially their motivation and self-confidence in learning science. Though they were higher achievers, females expressed less enjoyment in learning science than did males. Males, more than females, stereotyped science as a male domain. Attitudes and past performance appeared to influence course plans for both males and females. Among the attitudes, student motivation and usefulness of science were the most important predictors for course plans. The path analysis showed that males and females differed in the order of importance and kinds of factors that shape their concentration decisions. For males, general achievement, motivation, and family climate were the most important factors to influence course plans positively and directly. In contrast, usefulness of science, general achievement, and teacher support were the most important factors

influencing female course plans. Home environment contributed more to male attitudes toward science and consequently to science concentration decisions.

The study suggested the following actions: improved achievement in junior high school years should be emphasized; teachers and parents should motivate and encourage students to select more science courses; and the unique value and usefulness of each science course should be explained to students as early as possible. Further research should examine, in a causal framework, factors influencing enrollment decline in specific areas, such as a Physical Science course designed for students taking advanced senior courses, Advanced Placement Chemistry, and other advanced science courses.

Session A-18

EFFECTS OF COMPUTER-BASED DIAGNOSTIC INSTRUCTION AND NON-DIAGNOSTIC INSTRUCTION ON LABORATORY ACHIEVEMENT IN GENERAL SCIENCE

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ABSTRACT

This study was conducted to assess the effects of computer-based diagnostic testing on laboratory achievement in a college-level general science course. Ninety-one preservice elementary teachers enrolled in four laboratory sections of general science were available for study. Intact classes were randomly assigned to one of two treatment groups. Only one instructor was employed in the study.

All subjects completed the same laboratory activities during a seven week period. Subjects in treatment group one (diagnostic group) were then provided access to a 22 item, multiple choice, computer-based diagnostic test. Upon completion of the test, a summary of the subjects' performance on various course objectives was provided. Therefore, subjects in this group were able to diagnose their own deficiencies in the laboratory portion of the course. Subjects in treatment group two (non-diagnostic) did not have access to the diagnostic test.

Following treatment all subjects were administered a teacher-made laboratory examination. Subjects in the diagnostic group also completed a brief attitude survey designed to assess the perceived usefulness of the diagnostic test.

Results from this study indicate that students provided with diagnostic instruction did not perform significantly better than the contrast group on the laboratory examination. Perhaps the lack of achievement difference can be attributed to the format of the diagnostic test. The test did not provide students with immediate feedback concerning their performance on each item, but only with a summary after completing the entire test. Approximately one half of the subjects in the diagnostic group reported the test could be improved by providing answers to the questions that they missed. Results of the attitude survey

suggest that students believe the diagnostic test was helpful in preparing from the laboratory exam. In addition, subjects report the testing procedure should be a regular part of the course.

Session A-18

LEARNING OUTCOMES OF COMPUTER PROGRAMMING INSTRUCTION FOR MIDDLE-GRADE STUDENTS: A PILOT STUDY

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ABSTRACT

This study investigated the effect on the growth of logical thinking skills of middle-grades students when taught computer programming using the BASIC language. A quasi-experimental design was used with 36 students randomly selected and assigned to one of two treatment groups: 18 students received no instruction in programming (the comparison group) and 18 students received programming instruction for 10 weeks (the experimental group). The Test of Logical Thinking (TOLT) was used as a pretest and posttest measure of logical thinking skills. The posttest scores were analyzed using analysis of covariance procedures with the pretest TOLT scores as the covariate. The results indicate no significant differences in level of logical thought at $p = .10$ ($F = 2.52$, $p = .12$).

Session A-18

THE EFFECTIVENESS OF A COMPUTER-ASSISTED-INSTRUCTION PACKAGE IN SUPPLEMENTING TEACHING OF SELECTED CONCEPTS IN HIGH SCHOOL CHEMISTRY: WRITING FORMULAS AND BALANCING CHEMICAL EQUATIONS

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ABSTRACT

In this study, the use of a commercial microcomputer software package was evaluated as a supplement to traditional instruction in general chemistry classes in a suburban high school. The unit of study during the experimental period consisted of writing and naming formulas, and balancing chemical equations. The experimental group received drill, review and reinforcement by using the microcomputer for lessons three days each week for a three week period. The control group used conventional paper-and-pencil worksheets for their lessons; all exercises on the worksheets had been generated by the computer software and were consistent between treatment groups in content, diversity and difficulty level.

The results of the study are summarized below by research question:

1. In supplementing traditional instruction in selected chemistry topics, do the attributes of microcomputer materials contribute to effective learning as measured by an achievement test?

In this study, the use of the microcomputer materials did not contribute to more effective learning on the selected topics; the control group students' scores were significantly higher on the achievement test than the CAI group mean.

2. Among chemistry students of differing levels of cognitive development, is CAI an effective supplement to traditional instruction?

Based on suggestions in some research literature that CAI may be especially effective for students of low cognitive development levels, achievement scores were analyzed between non-formal and formal operational students, as measured by Lawson's Classroom Test of Formal Operations. No significant interactions were found to favor either CAI or the control activity for students of differing cognitive levels.

3. As a result of using CAI in H. S. chemistry, do students have a more positive attitude toward computers, chemistry, and computer-assisted instruction?

In measuring attitudes toward computers, differential treatment effects were discovered between males and females as indicated by an interaction between treatment and gender. Females displayed attitudes toward computers that were nearly identical regardless of treatment group. Males' attitudes, however, were far more favorable toward computers in the experimental (CAI) group; especially favorable were males' attitude toward the use of CAI in chemistry instruction.

In an analysis of attitudes toward chemistry, females' attitudes were more favorable in the control (non-CAI) group; males' attitudes toward chemistry were essentially the same between treatment groups.

Other results reported included correlations of achievement and affective measures with demographic and other background variables. A preliminary error analysis scheme is also presented for determining sources of errors students make when learning to write and name chemical formulas.

Session A-19

THE ACHIEVEMENT OF POOR VISUO-SPATIAL STUDENTS IN INTRODUCTORY COLLEGE BIOLOGY

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ABSTRACT

Educators involved with the troubled learner have found that the addition of visuo-spatial exercises into the lesson often leads to greater learning and greater motivation in students. Indeed, it has been known for some time that classes in the sciences and mathematics require a modest level of spatial accuracy if mastery of the material is to occur. It was the intent of this study to find if students classed as poor in visuo-spatial aptitude were truely at a disadvantage in the study of introductory college biology.

One hundred and twenty college biology students were given a series of standardized pencil and paper tests to judge their visuo-spatial accuracy. The tests included tasks for measuring spatial orientation, visualization, and field dependency-independency. Students falling more than one standard deviation from the mean on any of the spatial tests were classified as low in spatial aptitude and made up one group of the study. A second group of students was randomly selected from the average and above average population. Consideration, however, was given to gender to assure an identical male-female ratio with the poor spatial group. A standard t statistic run on the test means verified a significant difference in spatial aptitude between the two populations.

The poorly spatial population was subdivided into an experimental and control segment to see if training on spatial exercises would have an effect on biology achievement. The planes through solid intervention, previously shown to successfully develop visuo-spatial aptitude, was performed with the poorly spatial students in the experimental group.

A second version of each pretest was administered to all the biology students at the end of the semester. The results of the tests indicate the poorly spatial students in the experimental group had significantly increased their spatial awareness over the semester. However, when the final grade in the biology course was checked to see if increased spatial awareness had any effect on academic achievement, none could be found. The students in the experimental group did not receive a significantly better grade

than their poorly spatial peers. Overall, both groups of poorly spatial students received grades at the lower end of the grading scale. It is felt that if the study was carried over a longer period of time, different results would be obtained. The study does reinforce the theory, however, that poor spatial aptitude is a detriment to students in biology.

Session A-19

AN ASSESSMENT OF THE QUANTITATIVE SKILLS OF STUDENTS TAKING INTRODUCTORY COLLEGE BIOLOGY COURSES

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ABSTRACT

The mathematical skills possessed by students taking introductory college biology courses were investigated. A list of 23 mathematical competencies was identified as part of the development of a 46-item multiple choice test to measure the extent to which students possessed these competencies. The Biomathematics Skills Test (BST) was administered at the beginning and end of the 1983 fall semester to students in introductory biology courses for science majors (BS 100) and nonscience majors (BS 105) at North Carolina State University. Eight hundred and four students took the pretest, but only 354 took the posttest. The overall average for the pretest was 70% for BS 100 students and 65% for BS 105 students.

The relationships between the mathematical skills possessed by students at the beginning of the semester as shown by the BST pretest and 15 variables dealing with selected student characteristics were examined. There were significantly positive correlations for 12 of 15 variables in the case of BS 100 pretest scores and 11 in the case of BS 105. Males did significantly better on the pretest than did females in the case of BS 100, but there were no significant differences in the case of BS 105. Whites did significantly better on the pretest than did blacks in both courses. The means for a combined group of Hispanics, Indians, and Asians were not significantly different than for whites, but were higher than for blacks in BS 100.

The type of biology course (BS 100 or BS 105) taken was found to be significantly related to BST performance. The variable of taking or not taking a mathematics or statistics course during the semester was not significantly related to BST performance.

The BST pretest and seven other variables were used to determine the best predictors of success for the two biology

courses. SAT-Mathematics, SAT-Verbal, High School Grade Point Average, Age, and BST pretest were significantly predictors of success in BS 100. BS 105 predictors were High School Grade Point Average and BST pretest.

Session A-19

PREDICTION OF ATTRITION AMONG MALE AND FEMALE COLLEGE BIOLOGY MAJORS USING SPECIFIC ATTITUDINAL, SOCIO-CULTURAL, AND TRADITIONAL PREDICTIVE VARIABLES

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ABSTRACT

Although the proportion of college life sciences degrees earned by women is increasing, women remain underrepresented in the life sciences' labor force. A contributing factor in this underrepresentation is the difference in male and female attrition rates from undergraduate life science degree programs. Currently, attrition rates are considerably higher for females than for males, even accounting for academic performance. Consequently, the pool of potential scientists is losing proportionately more academically-capable young women than young men. It has been hypothesized that, since traditional ability measures such as grade point averages and SAT scores do not predict attrition as accurately for females as for males, additional factors must affect science attrition among young women. This study used attitudinal and socio-cultural variables as well as traditional variables to predict attrition from biology majors during the undergraduate years. Specifically, measures of science attitudes (including confidence, teacher attitudes, peer attitudes, and parental attitudes), science anxiety, causal attributions for success and failure in science, participation in extracurricular science activities, perceptions of future family/ career conflicts, and experience with science role models were assessed in addition to traditional predictive variables.

Students in four biology courses representing all four years of undergraduate work (freshman, sophomore, junior, and senior) completed a battery of instruments. Students received surveys during regular class hours throughout the semester and were allowed to complete response sheets at home. Bonus points in the biology courses were awarded for each completed survey; a return rate of 93% was obtained. The student sample was monitored for one calendar year. Attrition from biology majors was recorded

when students officially filed a request to change their major with the university.

Data were analyzed by use of ANOVA and discriminant and multiple regression analyses. In general, male and female students responded differently to some of the attitudinal and socio-cultural measures as did students in the four college-year groups (freshman, sophomore, junior, and senior). Furthermore, these attitudinal and socio-cultural measures made significant contributions to the prediction of attrition among undergraduate biology majors. Separate regressions for male and female students indicated that different factors may be important for retaining young women and young men in biology majors. Finally, the relative importance of each of the measured variables in predicting attrition was determined so that the most important factors could be targeted for future intervention programs.

Session A-20

APPLYING ROLE THEORY AND A CULTURAL MODEL TO UNDERSTANDING TEACHER CHANGE IN THE IMPLEMENTATION OF A NEW SCIENCE CURRICULUM

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ABSTRACT

The study examined the extent to which a new, inquiry-based, guided-discovery science curriculum implied change in normative role and role relationships of teachers and students and the extent to which change in role behaviors was evident during the year immediately following implementation. Concomitantly, the study was concerned with identifying parameters in the research setting and in the implementation process that contributed in a positive or negative way to accomplishing the kinds of changes implicit in the new program.

A long-term, case study approach was used involving extensive observations in classrooms of five cooperating teachers. Observations were undertaken at predetermined intervals during the year prior to as well as the year following implementation of the new program. Observations were also carried out during the teacher inservice program designed to orient teachers to the new program and an analysis was made of pertinent qualities of the curriculum materials. Focused interviews with key personnel in the implementation process viz: administrators from the Ministry of Education, inservice trainers, and curriculum writers provided additional data.

The research findings indicated that, although change in role and role relationships was central to the faithful implementation of the new program, there was little evidence of change during the year immediately following implementation. Lack of change appeared to be linked with the fact that dimensions of role and role relationships were largely unaccounted for in the channels of communication that existed for teachers to learn about the new roles expected of them. Hence, teachers had neither opportunities to observe and reflect upon, nor opportunities to assume and practice the kind of roles axiomatic to inquiry teaching prior to implementing the new curriculum in their classrooms.

Lack of role change also appeared to be linked with teacher perceived constraints which governed prevailing classroom

practices. These constraints encompassed dimensions of the research setting viz: the large class sizes, students' limited command of the English language, and the examination oriented nature of the education system at school and national levels. Although these parameters of the research setting did not relate to the new science program per se, they remained unaltered by the curriculum change effort and therefore continued to be a predominating influence on the way in which the teachers perceived and acted out their teaching roles.

Session A-20

PRESSURES FOR REFORM: A CASE STUDY OF THE ANTECEDENTS OF THE CURRENT "CRISIS"

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ABSTRACT

A perspective on current efforts at curriculum reform in science education is gained through a socio-historical case study of the events leading to the establishment of a physics revision committee in British Columbia in 1978. As a result of this committee, a PSSC based curriculum introduced in 1964 was replaced by one which gave greater emphasis to the social context of physics. Data are drawn from public and private sources of documents and from interviews with key actors. The data have been interpreted using, as a starting point, Goodson's model of influence of school subject communities on the making of curriculum. This model focuses on the way a community acts to protect and enhance its resources, territory and status. Discontinuities were found between the types of concerns expressed by teachers and the nature of the curriculum change authorized.

Teachers' concerns centered on achieving a course suitable for a wider range of students but retaining a traditional academic definition of school science. The introduction of a social context goal is thus seen as an anomaly to be explained. The ability of the science teachers' association to influence curriculum construction is constrained by its difficulties in obtaining information, achieving formal representation on committees and controlling agendas for discussion. Comparisons are drawn with the process of curriculum revision that took place in the early 60's. Implications for current efforts at curriculum reform are discussed.

Session A-28

PARENTAL INFLUENCE ON THE MATH ACHIEVEMENT OF GIFTED CAUCASIAN AND ASIAN CHILDREN

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ABSTRACT

Why are there so few female scientists, engineers, and mathematicians in the United States? Many researchers feel that this gender gap is due to socialization. This study examined the influence of parents on 339 gifted Asian and 354 gifted Caucasian children. Do the Asians socialize their daughters differently than do the Caucasians?

The results showed that the Asian parents did provide more encouragement to their females to pursue interests in mathematics than did the Caucasian parents. The gender gap was found to exist only for the Caucasians. The author concluded that socialization can be fruitfully studied by examining students for distinctly different cultures.

Session A-21

RELATING TEACHING BEHAVIOR AND CLASSROOM CLIMATE TO CHANGES IN STUDENTS' CONCEPTIONS OF THE NATURE OF SCIENCE

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ABSTRACT

An adequate understanding of the nature of science has persisted as a learning objective for secondary school science students for over three decades. Furthermore, this desired outcome is presently considered to be one of the primary attributes of the scientifically literate individual. Unfortunately, little is known about how the science teacher may promote adequate conceptions of science in his/her students. The purpose of this study was to determine which classroom variables are related to changes in students' conceptions of the nature of scientific knowledge.

Eighteen high school biology teachers/classrooms were compared with respect to students' conceptual changes on six aspects (i.e., amoral, creative, tentative, testable, parsimonious, unified) of the nature of science as measured by the nature of scientific knowledge scale (NSKS). In addition, comparisons of overall student changes were performed.

Thirty classroom variables significantly ($p < .05$) differentiated between the "high" group of teachers/classrooms (i.e. those exhibiting the largest student change) and the "low" group of teachers/classrooms (i.e., those exhibiting minimal student change) on at least five aspects of the nature of science. In general, teachers/classrooms in the "high" group were typified by frequent inquiry-oriented questioning, little emphasis on rote memory, decreased seat work, and increased emphasis on depth, breadth, and accuracy of subject matter. In addition, teachers in these classrooms were more pleasant, supportive, and had established better rapport than those of the "low" group. Finally, implicit references to the nature of science were more commonly found in the "high" group.

Eleven additional variables were found to differentiate between "high" and "low" teacher/classrooms on less than three subscales of the NSKS. These classroom variables were considered to be scale-specific and their analysis provided some provocative results. For example, explicit teacher comments concerning the unified nature of scientific knowledge were significantly ($p <$

.05) more common to the "low" group on the NSKS unified subscale. Discussion of the arbitrary nature of specific constructs in science was significantly ($p < .05$) more common to the "low" group on the testable subscale. Extensive analysis of classroom transcripts provided explanatory data for each of the scale-specific classroom variables that were identified.

Session A-21

THE EMPHASIS ON SCIENTIFIC LITERACY IN HIGH SCHOOL SCIENCE INSTRUCTION

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ABSTRACT

The purpose of this study was to investigate the ways in which aspects of scientific literacy were included in secondary school science instruction for students at different levels and with different interests. The degree to which scientific literacy was a focus and the perspective teachers on it as a goal were also concerns. This study is part of a two-year multi-site case study investigation of the organization and emphasis of science programs in a sample of six high schools. The overall approach of the study has been qualitative in nature. Methods included both observations and interviews, as well as a questionnaire. A total of 59 classrooms and a wide range of courses were included.

Findings showed that, while there were exceptions, many teachers interviewed during the study had only slight familiarity with the term scientific literacy, and had paid little attention to the national debate on the issue. In a survey of instructional goals, most teachers emphasized science facts and scientific method in their courses, regardless of the level or interests of the students enrolled. Quantitative assessment of time use during instruction showed that, in general, a very small percentage of time was devoted to aspects of scientific literacy. Narrative descriptions of classroom instruction revealed that these often were peripheral to the main topic of the lesson and were discussed in asides or anecdotes. Certain teachers, however, made fostering scientific literacy an integral part of their instruction.

Session A-21

THE RELATIONSHIP OF TEACHERS' USE OF SCIENTIFIC LITERACY AND GENERAL TEACHING SKILLS TO STUDENTS' ATTITUDES AND ACADEMIC GROWTH IN LIFE SCIENCE

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ABSTRACT

What, if any, combination of teacher effectiveness and scientific literacy skills relate to student growth on a range of science outcomes? To answer this, 7th-graders in 11 life science classes completed pre- and post-batteries of science measures. Observers visited each class during the entire presentation of two topics and made detailed narratives; in addition, they recorded teachers' time use and rated each teacher on a number of generic skills. Initial results show overall decline in students' attitudes but growth on cognitive measures, with considerable variation among classes. This study will attempt to identify variables that relate to this differential growth by means of having several sources of quantitative and qualitative teacher data. Furthermore, a comparison of the importance of "scientific literacy" versus "generic effectiveness" teacher behaviors is possible, and may thus contribute to our methodological and substative understanding of research on teaching in specific subject realms. In any case, the results of this study should point to the kinds of areas where concentrated teacher education efforts can contribute to the revitalization of science instruction.

Session B-1

USING COMPUTER GRAPHICS AND ANIMATION IN TESTING

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ABSTRACT

The graphics and animation capabilities of computers offer a new dimension in testing. Results from paper and pencil tests may not reflect true ability because of reading comprehension or visualization problems. Computers can present simulated actions and events that are the focus of test questions. The computer animated questions should then be more like learning situations and the real life situations to which learning is applied.

In this study middle school students completed either a paper and pencil or computer presented test of problem solving skills. Reading comprehension and visualization ability scores were also obtained. Interviews were conducted to assess the students' ability to comprehend test items. Analysis of the data showed no difference in test scores for the two groups -- a finding contrary to that in other studies using picture-enhanced printed tests. Visualization had no effect on the scores of either test type. The interview data showed no difference in student comprehension of the items.

Relatively low reading ability may have been a major contributor to the lack of an experimental effect in this study. Students had to read the interrogative portion of test questions even though the problem situation was dynamically presented with computer graphics and animation. Familiar problem contexts may also have contributed to the no difference result. Students were familiar with objects and events depicted in the items. The use of common experiences may dilute the visual effect of the computer graphics.

Session B-1

THE DEVELOPMENT OF A TEST OF BASIC PROCESS SKILLS IN SCIENCE

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ABSTRACT

The objective of this project was to develop a reliable multiple choice test of six basic science process skills appropriate for students from grades three to eight (ages 9 to 14). Most instruments now available focus on measuring all science process skills and/or were created for use with teachers. In recent years Dillashaw and Okey created a valid and reliable test of integrated science process skills intended for use with students in middle and secondary schools. No such instrument is available for measuring the basic science process skills, however. Therefore, this research is an effort to develop such an instrument.

In light of this need, the investigators began to develop the Test of Basic Process Skills in Science (BAPS). The following criteria were outlined for the test:

1. An emphasis on the six most widely used basic science process skills, i.e. observation, inference, prediction, measurement, communication and classification;

2. A multiple choice, four option, format;

3. An emphasis on using pictures and drawings to clarify and enhance items;

4. An average test readability below the fourth grade level;

5. Test length that permits completion within one class period (45 minutes or less);

6. A wide range of difficulty of items addressing each process skill, and;

7. Content free test items.

Objectives for each of the six basic process skills were written and refined. These objectives were reviewed by several experienced science educators and found to be valid representations of the intended skills. Multiple choice items were written for each skill. Problem content was chosen so as to be appropriate for elementary and middle grade students. All items were subjected to a readability analysis. An average index of 3.95 was obtained. The resulting 36 item test was submitted to a panel of four science educators to determine content validity. The results showed strong evidence of content validity.

One hundred and thirty-three 4th, 6th and 8th grade students were administered the BAPS test. The purposes of this test administration were to establish test reliability and to compute item difficulty and discrimination indices to aid in further test revision. Scores ranged from 4 to 33 correct ($\bar{X}$ = 22.4, S.D. = 5.3). The overall reliability (KR-20) of BAPS was .78. Item difficulties averaged .62. Point biserial correlations (discrimination index) showed 30 of 36 items above .20, with an average value of .34. All incorrect alternatives had point biserial correlations in the zero or negative range.

The present version of BAPS was shown to be a reliable and content-valid test of six basic science process skills appropriate for use with fourth through eighth graders. Test revision continues; it is hoped that for the revised second version of the test all test items will show improved indices.

Session B-1

DEVELOPMENT AND VALIDATION OF ESSENTIAL COMPUTER LITERACY COMPETENCIES FOR SCIENCE TEACHERS

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ABSTRACT

This study uses a five step process to establish and validate the essential computer literacy competencies for science teachers (K-12). That rigorous procedure will produce a concise list of competencies that are not only representative of the broad field of computer literacy skills but which also have been condensed to those competencies that are essential for teachers.

The essential computer literacy competencies for science teachers, developed in this study, will be used to develop a test for measuring the computer literacy of science teachers, and to develop a curriculum for training science teachers to use the computer. The test and curriculum for training science teachers will facilitate the successful implementation of educational computing.

Session B-2

THE ROLE OF TARGET STUDENTS IN THE SCIENCE CLASSROOM

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ABSTRACT

The study was conducted in grades 8 to 12 in two Western Australian high schools. Teachers frequently taught to the class as a whole and involved students through their answers to questions. The whole class setting seemed to allow teachers to manage the pace and type of activities and the type of student engagement so that the planned work was completed. As a consequence, teachers taught in a whole class interactive mode for a significant proportion of the time and tended to interact with target students who could provide the required responses to key questions or directions. Non-target students were not involved to a noticeable extent in interactions designed to stimulate thinking or to provide a bridge to a new content area.

Two types of target student were distinguished: the student who actively participated in classroom interactions in a self initiated manner; and the student who participated as a consequence of being selected by the teacher. These two types of target student corresponded to students with an internal locus of control and to students with high formal reasoning ability respectively. Compared to non-target students, target students tended to perceive the learning environment in a more favorable manner. There was also a tendency for target students to be male rather than female in grades 8 to 10. This trend was not apparent in grades 11 and 12.

Session B-2

RELATIONSHIPS OF ATTITUDE TOWARD CLASSROOM ENVIRONMENT WITH ATTITUDE TOWARD AND ACHIEVEMENT IN SCIENCE AMONG TENTH GRADE BIOLOGY STUDENTS

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ABSTRACT

The classroom is the basic structural unit of our educational system. This environment is where a large number of interactions occur among students, teachers, peers and curriculum. These interactions create an environment that affects both attitudes and achievement of students. The purpose of the study was to examine the relationship of classroom environment to attitudes toward science and achievement in science among tenth grade biology students.

Data were obtained from tenth grade students in four senior high schools. There were 1560 students enrolled in 70 biology classes. Instruments were administered at three times during the school year to measure student attitudes toward science and the classroom environment. The classroom environment measure examined six areas: emotional climate of the science classroom, science curriculum, physical environment of the science classroom, science teacher, other students in the science classroom, and friends attitudes toward science. Student achievement in science was measured by teacher reported semester grades.

The major findings of the study were as follows:

1. Student attitudes toward the classroom environment predicted between 56 to 61% of the variance in attitudes toward science.

2. Student attitudes toward the classroom environment predicted between 5 to 14% of the variance in achievement in science.

3. Student attitudes toward science and attitudes toward the classroom environment predicted between 8 and 18% of the achievement in science.

4. There was a weak positive relationship between attitudes toward science and achievement in science.

Session B-2

USING SHORT FORMS OF SEVERAL CLASSROOM CLIMATE INSTRUMENTS TO ASSESS AND IMPROVE CLASSROOM PSYCHOSOCIAL ENVIRONMENT

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ABSTRACT

Despite international interest in research in the area of classroom environment, very little attention has been given to exploring how science educators might apply ideas from the field of classroom environment in facilitating practical improvements in science classrooms. Techniques are proposed for improving school classroom environments by using student perceptions as a basis for reflection upon, discussion of, and systematic attempts to improve classrooms. The basic logic involves, first, using assessments of student perceptions of both their actual and preferred classroom environment to identify discrepancies between the actual environment and that preferred by students and, second, implementing strategies aimed at reducing existing discrepancies.

Practical constraints inhibiting science teachers' use of classroom environment assessments in guiding improvements in classrooms include the lack of easy access to instruments and the lack of economy of existing instruments in terms of testing and scoring time. Consequently, in order to facilitate teachers' use of classroom climate assessments, we developed economical short forms of the Classroom Environment Scale (CES), Individualized Classroom Environment Questionnaire (ICEQ), and My Class Inventory (MCI) which contain only approximately 25 items each and which are amendable to easy hand scoring. When each instrument was administered to samples of at least 100 science classes, results supported each scale's internal consistency reliability, discriminant validity, and ability to differentiate between the perceptions of students in different classrooms.

The methods for improving classrooms are illustrated by reporting three small-scale studies, one for each of the three instruments. For example, actual and preferred forms of the CES were used by a teacher in an attempt to improve the environment of

his ninth grade science class consisting of 22 boys and girls of mixed ability. The steps followed were: (1) assessment (the actual and preferred forms were administered), (2) feedback (the teacher considered profiles of mean class scores and identified actual-preferred discrepancies), (3) reflection and discussion (leading to a decision that the teacher would attempt to increase Teacher Support and Order and Organization), (4) intervention (aimed at increasing these two aspects), and (5) reassessment (readministration of classroom environment instruments in order to detect any changes in environment). An examination of CES mean score profiles for the teacher attempting improvements indicated that some clear changes in classroom environment had occurred during the two months when the intervention was being tried. It was found that significant improvements occurred for the two dimensions, and only the two dimensions, on which change was attempted (i.e., Teacher Support, Order and Organization).

Session B-3

INTERRELATING GENERAL SCIENCE CONTENT: A FOCUS FOR THE MIDDLE SCHOOL

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ABSTRACT

The intent of this study was to determine whether students experiencing resequenced and overtly interrelated general science content with respect to clarifying content structure would exhibit higher science achievement, more positive attitude toward science, and greater interest in science when compared to a control group of students experiencing the same content not resequenced. Conclusions found in the literature of science education may be interpreted to provide evidence that greater understanding and retention of material is associated with bodies of knowledge whose contents of subject matter are interrelated for learners. Data were collected from 203 sixth grade science students after one year by way of a standardized achievement test, and two Likert-type instruments which measured the two affective variables. Statistical procedures included the t-test for examining differences between the experimental and control groups. The results indicated that students experiencing resequenced general science content were significantly more positive in terms of science achievement, attitudes toward science and interest in science. The conclusion was formulated that establishing content structure through resequencing chapters for general science learners has positive effects on both cognitive and affective aspects of learner performance. Implications for relating content structure to science classrooms, and curriculum and textbook revision have been discussed.

Session B-3

COMPREHENSIVE ANALYSIS OF THE TEACHING AND LEARNING OF SCIENCE TOPICS: A RESEARCH PROGRAM FOR SCIENCE EDUCATION

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ABSTRACT

An emerging research program is described which focuses on the teaching and learning of specific science topics by coordinated analysis of curriculum materials, teachers' planning and intentions, actual classroom instruction, and changes in student knowledge. The program draws on recent advances in cognitive science, philosophy of science, and ethnographic-sociological studies of classrooms for both theoretical perspectives and methodology.

Studies have shown that a majority of students often fail to understand science topics that they study and have elucidated important factors contributing to this failure. In particular, students often bring with them naive conceptions of science topics they study. Such naive conceptions lead them to interpret instruction in ways that are not anticipated by teachers or make it difficult for them to comprehend at all.

Several studies have reported very substantial gains in the proportion of students coming to understand the topics taught when instruction was based on information about likely student naive conceptions and strategies designed to challenge them while promoting scientific alternatives. Comparisons of more and less successful instruction have led to the identification of features of instruction which promote conceptual change and student understanding.

Our interpretations of these studies is that the substantial improvements in student learning could be attributed primarily to teachers coming to view learning as involving a change from naive to scientific conceptions and their acquisition of topic-specific information about content, student naive conceptions and teaching strategies for attacking them.

This interpretation of these important studies implies that teacher education could contribute to substantial improvement in student learning by helping teachers develop conceptual change views of learning and acquire and learn to use essential topic-specific knowledge. Curriculum developers could contribute by designing materials that help teachers develop conceptual

change views of learning and provide topic-specific information in useful forms. All of this implies a need for research to build the necessary knowledge base and evaluate the various efforts. The bottom line should be demonstrated improvement in student learning, that is, in the proportion of students demonstrating understanding of the science topics they study.

Session B-3

SCIENCE AND MATH RESEARCH PROGRAMS IN EXEMPLARY SCHOOLS

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ABSTRACT

Many of the programs of exemplary schools have student research programs in math or science. This study utilized objective criteria (Westinghouse and other national awards) to isolate the most important components of student research programs in a number of exemplary schools.

Data were collected from 137 schools, including a large number of exemplary schools in the New York metropolitan region.

The results of the study showed that exemplary schools have developed specialized programs to foster excellence in student research. The key variables in these programs involve making contact with universities, isolating responsibility in a single qualified teacher, and establishing contact with a technical library.

The programs were found to be cost-effective and well within the resources of most comprehensive high schools.

Session B-4

AN INTERNATIONAL CONSORTIUM FOR CONCEPT LEARNING RESEARCH IN FOUR COUNTRIES (U.S.A., TRINIDAD AND TOBAGO, COSTA RICA, AND MEXICO)

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ABSTRACT

Research in education is very much influenced by the specific samples and conditions of the research. It becomes extremely important to have replication of research in order to identify those findings which have stability and consequently the generalizability needed to build a knowledge base. In order to establish a broad base it is valuable, and perhaps necessary, to have cooperative efforts in a variety of settings to test the hypotheses and the practical application of the theories.

The first level of cooperation at the university was between the main campus faculty and the branch campus faculty. This provided a broader base for sampling and a valuable perspective for the needs and adjustments for experimental procedures.

In addition, cooperative efforts in the form of an international consortium have been developed. The needs, resources, and cultural differences of the institutions and their representatives from Costa Rica, Trinidad and Tobago, and Mexico provide opportunities for:

A. replication to establish new generalizations or reaffirm previous ones,

B. expansion of the generalizations to a broader population,

C. identification of the differences in populations and the relevance of the generalizations,

D. extension of the generalization to other modes, and

E. clarification of the concept of transition as a part of cognitive development.

This symposium will provide the opportunity for an international perspective on the role of research in the improvement of science education in particular and education in general. The representatives of each of the countries (Costa Rica, Trinidad and Tobago, Mexico and the United States) will discuss the following factors:

A. Goals and directions for science education research in the country;

B. Needs and resources for effective science education research in the country;

C. Role of a science education research consortium in the improvement of the research program in the country.

The current topic of research is the use of technology to facilitate the transition of young children from concrete understanding of concepts to abstract thought.

Session B-5

WHAT RESEARCHERS SHOULD KNOW ABOUT TEACHERS' PRACTICAL KNOWLEDGE

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ABSTRACT

When teachers make decisions on what to teach and how to teach it, they draw upon their past experiences, current expectations and personal values. They do this explicitly or implicitly within their own practical "paradigms."

In order for research to influence the improvement of instruction, classroom teachers must hear and value the researcher's message. Being heard and valued by teachers depends upon the researcher's ability to communicate, or even collaborate, within the teachers' practical paradigms. A better understanding of these practical knowledge paradigms could help researchers in (1) formulating research problems, and/or (2) effectively communicating research findings to teachers.

The symposium will not offer polemics, but rather will share findings from empirical studies. Three presentations provide a description of two different perspectives on teachers' practical knowledge: functional paradigms and narrative unities. The first paper develops the notion of functional paradigm and illustrates it with data from four different studies in elementary and secondary schools. The second paper reports on an investigation that explored the functional paradigms of high school chemistry teachers. The third paper illuminates an alternative view, narrative unities, and shows how this notion serves to understand the events that occur in elementary school classrooms. The presenters, university researchers and a classroom teacher, will discuss these findings in terms of what researchers should know about teachers' practical knowledge.

Session B-7

THE IMPACT OF COMPUTER-BASED EDUCATION ON STUDENT ACHIEVEMENT

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ABSTRACT

The purpose of this symposium is to summarize what is currently known about how Computer-Based Education (CBE) influences student achievement, to outline projected directions for future CBE research, and to describe selected research design and data analysis techniques suitable for answering questions related to the effects of CBE on student achievement. Simply defined, CBE is the use of computers to enhance learning. With the introduction of the microcomputer, a variety of educational applications for computers has been examined. Many of these applications have been found to directly influence student achievement. However, other applications have demonstrated little or no influence on student achievement.

Which educational applications of computers have been found to influence achievement? Which additional applications of microcomputers might influence achievement? How can questions like these be effectively researched in the schools? Answers to these questions would directly influence how schools choose to employ microcomputers in their curricula. However, lacking this knowledge, schools will be unable to implement those CBE applications which would be most beneficial to increasing student achievement.

Session B-8

ACTUAL AND PREFERRED CLASSROOM LEARNING ENVIRONMENT AS PERCEIVED BY HIGH SCHOOL SCIENCE STUDENTS

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ABSTRACT

Studies in different countries have shown that students tend to prefer a more positive learning environment than actually exists in their classrooms. The goals of this study were to replicate these findings, in high school chemistry and biology classrooms, and to compare students' perceptions of the actual and preferred learning environment. Biology and chemistry subject matter were selected since, while these topics are interrelated regarding their content, they differ in the method of instruction used in high schools in Israel. The actual and preferred versions of the Learning Environment Inventory (LEI) was administered to 11th grade biology (N=400), and chemistry (N=1080) students. Thus a total of 1480 high school students participated in this study. Data were collected by a paper and pencil questionnaire, using a Likert type scale. Students' mean scores were tested by a multivariate analysis method. The results yielded significant differences between biology and chemistry students' perceptions of their actual and preferred learning environment of their classroom. These differences are explained and discussed on the basis of the different instructional methods used by chemistry and biology teachers in their classrooms. The findings of this study can serve future science curriculum developers as well as science teachers in their classrooms.

Session B-8

AN IMPLEMENTATION STUDY: AN ANALYSIS OF ELEMENTARY STUDENT AND TEACHER ATTITUDES TOWARD SCIENCE IN PROCESS-APPROACH VS. TRADITIONAL SCIENCE CLASSES

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ABSTRACT

During the 1982-83 academic year the Richardson Independent School District (RISD) conducted audits to assess the status of science education in the district. Such audits were in anticipation of Texas House Bill 246 (TAC Chapter 75) which requires an inquiry-oriented, process-approach to the teaching of science. In general, it was found that the process-approach was not in wide usage by teachers in RISD. In response to those data, RISD established the Elementary Science Pilot Project and adopted the Science Curriculum Improvement Study (SCIIS) as part of the new K-6 Science Through Discovery curriculum.

The overall goal of the Elementary Science Pilot Project is to implement a science curriculum that emphasizes inquiry-oriented, process-approach science. Concomitant goals are to broaden teacher knowledge so that curriculum development efforts will be relevant and to enhance teacher attitudes toward science.

One of the major objectives for 1983-84 was to evaluate the effectiveness of the first year of a three year implementation plan. The present study assesses and analyzes the attitudes toward science of the teachers and students in SCIIS classes compared to teachers and students in non-SCIIS classes. The student attitudinal data are also compared to national norms. Significant attitudinal differences were noted between SCIIS and non-SCIIS students, while their teachers possessed similar attitudes. Such data would appear to suggest that the nature of process-approach science allows SCIIS teachers to portray a much

more positive and exciting image of science and scientists. Additional aspects of the total implementation plan will also be discussed.

Session B-8

A STUDY OF THE IMPLEMENTATION OF THE NATIONAL BIOLOGY PROGRAM IN THAILAND

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ABSTRACT

The IPST Biology program was developed and implemented initially in Thailand in 1976, and is the national curriculum which all biology teachers are to use. This study examined the nature and extent of implementation of the program at the 10th grade level in Bangkok. The assessment strategies were developed as part of the Concerns Based Adoption Model by the R & D Center for Teacher Education at the University of Texas at Austin. These included the Stages of Concerns (SoC), the Levels of Use (LoU) and the Innovation Configuration (IC). The instruments were translated and reliabilities (.90 or higher) established on a test-retest analyses.

The SoC showed that teachers had intense informational and personal concerns and unusually high refocusing concerns. The LoU results showed that 17% were not using the program and 40% were making changes in it. An estimated 80% expressed concern that IPST Biology needed more "content" in order to prepare students for university entrance examinations. The SoC and LoU data suggest that teachers were anxious about the content of the program and want to move it away from the more global (science literacy) goals toward the academic goals.

It appears that CBAM is a useful tool for understanding implementation of programs in non-USA situations. Developers and facilitators of curriculum should consider the change literature in their work and the teacher variable should be considered in curriculum design.

Session B-9

THE PORTRAYAL OF EDUCATIONAL DIVERSITY WITHIN A LARGE-SCALE STUDY OF SCIENCE CURRICULUM MANDATES, TRANSLATIONS, AND OUTCOMES

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ABSTRACT

The purpose of this paper set is twofold: 1) to report the results of work carried out within the context of a large-scale study of relationships among science curriculum mandates, translations, and outcomes, and 2) to stimulate interest in the examination and possible reconceptualization of current models of the effects of schooling on student learning.

The proposed format consists of four closely related papers presented by people working on the project. The first paper presents an overview of the conceptual structure of the project and makes problematic issues involved in conceptualizing the study of curriculum translations and outcomes in a more holistic or context-embedded way than is often suggested by linear input-output models. The second paper addresses the study of curricular diversity. An approach to the identification, analysis, and protrayal of curriculum diversity is described and the results of its application to sets of twelve different mandated curricula within each of elementary science, middle school science, and senior high science are presented. The third paper makes problematic the process by which the intended or mandated curriculum is transformed by teachers. Teachers are viewed as interpreting curriculum materials in an interactive

manner within certain bounds established by what is referred to as teacher functional paradigms.

The fourth paper describes influences of the curricular contexts, the personal context, the instructional context as created by the teacher, and the school environment as perceived by the student, on student achievment patterns. Results are based on a national sample of over 22,000 students at the elementary, junior high, and senior high levels.

Session B-10

AN INVESTIGATION OF SEVERAL VARIABLES INVOLVED IN CHEMISTRY PROBLEM SOLVING

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ABSTRACT

Success in solving science and mathematics problems evidently depends upon variables such as content knowledge, level of intellectual development, the use of heuristics, the ability to construct an appropriate problem representation and the number of errors committed that remain uncorrected. This study was an effort to learn more about the effect of these and other variables on success in solving chemistry problems.

The subjects in this study were thirty college chemistry students and one college chemistry professor. The subjects were required to demonstrate proficiency in basic algebra, chemistry, and cognitive skills as a prerequisite for solving the target chemistry problems. The subjects individually solved chemical stoichiometry problems using the think-aloud technique. Each session was audio-recorded for subsequent analysis of problem solving techniques and chemistry content.

Both written work and transcripts made from verbal reports served as the data base. Analysis of the data was facilitated by use of a coding form. A coding form was used by the judges analyzing the written work and transcripts of each subject. A high degree of inter and intra judge reliability on the use of the coding form was demonstrated. Factor analysis, all possible regressions, and the T-test were three statistical techniques employed in the quantitative approach to data anlaysis.

Results of the statistical analyses indicate that the following variables are important for successful chemistry problem solving: correspondence in problem representation, coherence in problem representation, connectedness in problem representation, organization of written work, effective use of heuristics, persistence, and ability to correct errors that are committed during the problem solving process.

Results of the descriptive analysis indicate that successful problem solvers were able to construct and use appropriate representations. Unsuccessful problem solvers did not construct an appropriate problem representation. Unsuccessful problem solvers focused on inappropriate balanced equations and relied heavily on the use of algorithms.

Session B-10

THE EFFECT OF TASK CONTENT UPON PERPORTIONAL REASONING

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ABSTRACT

A long standing issue in cognitive psychology is the question of content effects upon problem solving skills, i.e., do student's problem solving abilities generalize across specific subject matter domains? Although Piaget argued that formal reasoning strategies are independent of content, the well known decolages of Piaget can be interpreted as evidence that student's reasoning skills or problem solving performance is influenced by the subject matter content of the problem. Some researchers have suggested that one's familiarity (prior knowledge) with the subject matter domain influences one's level of problem solving performance.

This investigation reports the findings of a study of ninth grade student's proportional reasoning ability with familiar (naturalistic) and unfamiliar (high school science subject matter) content. Proportional reasoning is defined conceptually. A test is administered to about 100 ninth grade students and the results are interpreted in terms of the issue of content effects upon reasoning and problem solving.

Suggestions for further research are described.

Session L-10

THE EFFECTS OF THE ABILITY TO ENCODE AND COMBINE PROPOSITIONS ON THE DEVELOPMENT OF REPRESENTATIONS FOR PROBLEM SOLVING IN GENETICS

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ABSTRACT

The purpose of this pilot study was to propose and test a model for the development of representations in genetics problem solving and to determine the effect of the ability to encode and combine propositions on the development of representations for a multihybrid cross problem. The model consists of different representation systems and interrelationships among these systems.

The tests used in this study were the multiple cross problem, the Propositional Logical Test (PLT), and the Pieces task. The PLT measures the ability to encode propositions while the Pieces task measures both encoding and combining propositions.

This sample was obtained from a two-year college in New York; the students were enrolled in the second semester of a general biology course. For this sample, the multihybrid cross problem and the encoding and combining tasks proved to be very difficult. Most subjects used some form of verifying strategy to work the PLT and the Pieces tasks. The model provided an appropriate framework in which responses to the multihybrid cross problem and the tasks could be studied.

Session B-11

THE RELATIVE EFFECTIVENESS OF MICROTEACHING AND FIELD EXPERIENCE ON PRESERVICE TEACHERS

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ABSTRACT

This paper presents the results of a study designed to determine whether preservice elementary teachers with a great deal of previous early field experience but no previous microteaching experience would benefit more from an additional science field experience in the local school systems or from an alternative science microteaching experience. Previous studies have shown how both practices independently are beneficial to preservice teachers but little previous work has been done to determine whether these two methods interact or complement each other when combined in a teacher training program. Subjects for the investigation were enrolled in two sections of an elementary science methods course. Subjects were randomly assigned to an experimental (microteaching) group and a control (field experience) group.

At the end of the treatment, which lasted a full semester, students were evaluated on four outcome measures selected because of common use in previous investigations in these fields. These included teaching behaviors rated from video tapes made of all students teaching a lesson at the end of the semester. Lessons were rated on an instrument developed for this investigation. Other instruments included one to measure science process skills, attitudes toward science and science teaching, and a measure of student concerns about teaching science.

Mean differences on these research instruments were analyzed by means of t-test procedures. Results showed that the microteaching group scored significantly better than the field experience group on three of the five instruments used to measure outcomes of the study. They scored significantly better on measures of science teaching skills, attitudes toward science, and science process skills. There were no significant differences

between groups on measures of attitudes toward teaching science or on concerns about teaching science.

The study concludes that integrating science microteaching with field experience in undergraduate methods courses is superior to field experience alone in developing science teacher skills, attitudes toward science, and science process skills than. The lack of significant differences between groups on the measures of attitudes toward teaching science and science teacher concerns indicates that these attitudes and concerns are at least not negatively affected when field experience is somewhat decreased in order to implement a microteaching program.

The study also suggests a need for further study of feedback systems in both practice teaching methods. The need to determine an efficient balance between the amount of field experience and microteaching utilized in undergraduate programs is also discussed.

Session B-11

THE EFFECTS OF TWO METHODS OF INSTRUCTION ON THE ACQUISITION AND RETENTION OF SCIENCE PROCESS SKILLS BY PRESERVICE TEACHERS

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ABSTRACT

This study compared the effects of two methods of instruction designed to teach preservice elementary teachers to acquire and retain integrated science process skills.

The subjects were 32 students who were randomly assigned to two sections of an undergraduate science methods course at a large southern university during the 1984 spring semester. Students in both sections participated in science activities taught by the instructors and in lessons presented by peers stressing integrated process skills. Students were asked to stress process skills as they taught small groups of elementary children during the field experience component of the course. In one section, instruction in the integrated process skills was provided by the teacher, while, in the other section, instruction was provided by written self-paced self-instruction materials.

A two-group, posttest-delayed-posttest design was used. Subjects were administered process skill measures at the end of the course and approximately five months later. Results of the 2 (treatment) X 2 (time) factorial ANOVA with repeated measures on the time factor indicated a significant main effect for treatment but not for time. There was no significant treatment X time interaction. Pre-planned comparisons revealed that at the end of the semester and five months later, students using the self-paced instructional materials significantly outperformed students taught process skills by an instructor ($p < .002$, $p < .014$).

The findings indicate that science process skill acquisition can be enhanced by supplementing teacher instruction in process skills with self-paced, self-instructional materials. It appears that focusing attention on process skills and providing opportunities for prospective teachers to plan and execute lessons stressing process skills does not insure that they will learn

those skills. However, students who learn the skills seem to retain them over a long period of time.

Session B-11

AN EVALUATION OF THE EFFECTS OF AN ENVIRONMENTAL INVESTIGATION COURSE ON TEACHER SCIENTIFIC KNOWLEDGE AND SELF-CONCEPT

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ABSTRACT

An evaluation was conducted to provide the data required to make judgements concerning the merits, worths, and shortcomings of the Environmental Investigations program. The Environmental Investigations program curriculum had been developed to train science teachers. The curriculum was divided into a Camping Phase and a Fieldtrip Phase.

An ancillary problem investigated by this study was to validate a model illustrating proposed relationships between scientific knowledge, self-concept, and attitudes toward science.

A formative evaluation was conducted during the planning and implementation phase of the Environmental Investigations program. This formative evaluation considered antecedent, transaction, and outcome variables. A summative evaluation was conducted upon completion of the program.

Data were collected in a pre-posttest design. The formal instruments used in this study were: Environmental Science Test, Tennessee Self-Concept Scale, Attitude Toward Science Scale, and Attitude Toward Teaching Science Scale. The informal instruments used in this study included: Personal Information Form, student journals, and final exam items. Additional data were collected using a post-course mail survey.

The results of the analysis of the data indicated that the Environmental Investigations curriculum was worthy of adoption. This judgement was made based on results which included: increase in scientific knowledge, increase in self-concept, and increased attitudes toward science. Also, the mail survey indicated that the activities and materials in the Environmental Investigations program were appropriate for use in the classroom. The results indicated that scientific knowledge and self-concept are related to science attitudes. The correlation between self-concept and science attitudes were statistically significant. The posttest data indicated that this correlation was strengthened by the Environmental Investigations program.

This study developed a useful model for the evaluation of educational programs. This model does not limit judgements concerning program worth solely to increases in student knowledge. It also considers efficiency, effectiveness, an appropriateness factors in judging program worth. The results of this study also support the proposed model for the relationships between scientific knowledge, self-concept, and science attitudes.

Session B-13

ACADEMIC TASKS IN SECONDARY SCIENCE CLASSROOMS

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ABSTRACT

This paper set contains a report of research that utilized an academic task framework to examine learning experiences in secondary science classes. Each paper presents findings and perspectives based on one or more science classes included in the Managing Academic Tasks (MAT) Study, a study focusing on the intellectual demands of academic work and the ways that work is carried out in secondary classrooms.

The first paper, "Task Systems, Content, and Meaning in Secondary Classrooms," presents an overview of the theory, methods, and findings of the MAT study. The academic task systems observed in two junior high science classes are contrasted, and several themes emerging from analyses of the junior high case studies are discussed. In "Studying Genetics: A Case Study of Tasks and Content in High School Biology," the author provides further illustration of how the academic task model can provide new perspectives on student learning opportunities and teaching in science classes. Finally, "Academic Tasks and Research in Science Teaching" considers the utility of the academic task model for addressing some specific themes and enduring problems of research in science education.

Session D-14

A PROFILE OF THE NEEDS AND CONCERNS OF ENGLISH SPEAKING PUBLIC SECONDARY SCIENCE TEACHERS FROM FIVE GEOGRAPHIC REGIONS OF THE REPUBLIC OF LEBANON

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ABSTRACT

The purpose of this study was to identify the needs and concerns of English speaking public secondary school physics, chemistry and biology teachers in the five geographic regions of the Republic of Lebanon. Such needs and concerns ought to constitute the essential and legitimate background on which designers of in-service programs should build different activities that aim at renewing and updating the skills and knowleldge of Lebanese science teachers. It is anticipated that this would eventually lead to the improvement of science teaching in the Republic of Lebanon.

A set of three questionnaires was used to conduct the study: a demographic questionnaire, a modified version of the Moore Assessment Profile (MAP), an instrument which had been developed to assess the needs of secondary science teachers, and the Teacher Concerns Statement (TCS), an instrument that was based on the Concerns-Based Adoption Model (CBAM) and developed by the Research and Development Center for Teacher Education of the University of Texas at Austin. The study included all English speaking public secondary school science teachers in the Republic of Lebanon. Usable returns were received from a total of 65 science teachers (58%).

The results of the study indicated that physics teachers from the five geographic regions shared six high-priority in-service needs (A high-priority in-service need is a need that was rated as "much needed" or "moderately needed" by at least 50% of the teachers); chemistry teachers shared nine high-priority needs; and biology teachers shared twenty-one high-priority needs. Physics, chemistry and biology teachers across the regions had mostly medium level concerns (task concerns: issues related to management, efficiency, organization, scheduling, time demands, adequacy of curricula, and availability of instructional materials

and laboratory equipments), and high level concerns (impact concerns: issues related to the impact of teaching on students' performance and competence, and changes needed to increase student outcomes).

The high-priority needs and predominant concerns of public secondary physics, chemistry, and biology teachers in the different geographic regions of the Republic of Lebanon must be addressed if the conditions and effectiveness of science teachers in Lebanon are to improve.

Session B-14

A REVIEW OF THE STATUS OF HISPANIC AMERICAN STUDENTS IN SCIENCE

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ABSTRACT

Hispanic American students represent a large percentage of the Non-English Language Background (NELB) students in the schools. Despite their large numbers, little research has been undertaken to understand the science education needs of this population.

The purpose of this paper is to review the research related to the status of Hispanic American students in science. The review will focus on four areas of research:

1. The demographics of Hispanic Americans in scientific and technological fields of education and employment.
2. The science-related attitudes of Hispanic American students.
3. The science-related achievement of Hispanic American students.
4. Efforts to improve science instruction for Hispanic American students.

National reports of the status of minority groups suggest that Hispanic Americans are underrepresented in scientific and technological careers. Several barriers have been identified which may preclude the participation of minorities in science-related fields.

Results of the recent national assessment in science indicate that Hispanic American students achieve at a slightly higher level than black students, but that both black and Hispanic students achieve significantly below white students. This may be related to the significantly greater number of science experiences that white students receive.

While white students' attitudes have declined over the past five years, Hispanic students have remained fairly constant in their attitudes toward science over the same period of time.

The review begins to identify some of the influences toward science in general that may affect later course and career choice of Hispanic American students. It is clear that interventions within the school setting that might positively affect students' attitudes toward and achievement in science and scientific careers are needed early in students' school experience to later influence choice of science coursework and careers. Lack of participation in these areas by minority students must be considered a result of substantial influences blocking participation. Clearly, the status of Hispanic American students in science is affected by school and societal factors. Early exposure to science experiences, instructional strategies that include attention to a variety of cognitive styles and allow for personal attention and cooperative group activities may well be a start in the development of foundations for choosing science.

Session B-14

SCIENCE - TECHNOLOGY RELATED GLOBAL PROBLEMS: AN INTERNATIONAL SURVEY OF SCIENCE EDUCATORS

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ABSTRACT

Science - Technology - Society (S-T-S) has been suggested as a new conceptual organization for science education. This survey evaluated the one aspect of the S-T-S theme; namely, the teaching of global problems related to science and technology. The survey was conducted during Spring, 1984. Two hundred fifty-five science educators completed the survey. This was 78% of the original sample. Findings of the survey included a ranking of twelve global problems (the top five were: World Hunger and Food Resources, Population Growth, Air Quality and Atmosphere, Water Resources and War Technology). Science educators generally indicated the following:

1. The problems would be worse by the year 2000.
2. They were only slightly or moderately knowledgeable about the problems.
3. Print, audio visual media and personal experiences were primary sources of information.
4. It is important to study global problems in schools.
5. Emphasis on global problems should increase with age/grade level.
6. An integrated approach should be used to teach about global problems.
7. Courses including global problems should be required of all students.
8. Most countries are in the early stages of developing programs including global problems.
9. There is a clear trend toward S-T-S.

10. There is public support for including global problems and the most significant limitations (in order of significance) are political, personnel, social, psychological, economic, pedogogical and physical).

This survey has implications for the purpose, policies, programs and practices of science education.

Session D-15

THE ABILITY OF HIGH SCHOOL CHEMISTRY STUDENTS TO SOLVE COMPUTATIONAL PROBLEMS REQUIRING PROPORTIONAL REASONING AS AFFECTED BY ITEM IN-TASK VARIABLES

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ABSTRACT

This research study was designed to investigate the interactions of selected high school student aptitudes (developmental level, field dependence-independence (FDI), and proportional reasoning ability) with their ability to solve chemistry problems with varying structure and information. The secondary purpose was to investigate the relationships of gender with chemistry problem solving and student aptitudes.

Three aptitude measures (The Balance Puzzle, The Find a Shape Puzzle, and An Inventory of Piaget's Developmental Tasks) and 14 dependent chemistry quizzes were given to 77 high school students. Five chemistry concepts were covered by the quizzes. Within each quiz a number of in-task variables were identified: Piagetian logical structure-reversibility, algebraic format, type of information-relevant only or relevant and irrelevant, and nature of the information-explicit or implicit. All measures were administered over a period of fourteen weeks during the first semester of the 1983-84 school year. The statistical procedures used centered on correlations and analyses of variance.

Field independent students performed significantly better on the in-task conditions. The implicit information interaction being a unique contribution to the research on FDI. Degree of formal reasoning and proportional reasoning were found to be significantly correlated with success in chemistry, independent of the in-task conditions. Males significantly outperformed females on the proportional reasoning measure--The Balance Puzzle. No significant interactions were found between sex and chemistry achievement.

Three major recommendations were made as a result of the analyses of data. First, it was recommended that further study be conducted analyzing individual differences in aptitudes with problem solving as it takes place in natural settings, using

classroom examinations. Second, continued study should be given to the relationships of FDI with in-task conditions which vary in the type of information given, as well as additional study relative to varying the amount of information and/or the use of redundant information. Third, the interaction of implicit information with students' degree of FDI warrants expanded study.

Session B-15

THE LOGICAL REASONING NECESSARY TO MAKE LINE GRAPHS

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ABSTRACT

A three year study was conducted to determine the logical reasoning processes necessary to construct line graphs. Three types of line graphs were used: a straight line with a positive slope, a straight line with a negative slope, and an exponentially increasing curve. This area was chosen for investigation because of the importance in science of displaying information graphically. Previous research by other investigators was concerned with the accuracy of reading various types of graphs and with measuring graphing skills. This research determined the underlying logical reasoning processes needed to make line graphs.

The three research instruments used consisted of a set of instructions, data to make a graph, and two unlined pieces of paper. The subjects used were middle school and high school science and mathematics students who were allowed to use a ruler if they thought it necessary and were allowed as much time as needed to complete the task.

The responses were classified into one of nine categories. The categories ranged from no attempt to make a graph to complete graph with a statement of a relationship between the variables. The categories in between represented increasingly more successful attempts at ordering data in one and both variables to correct scaling of the data on the axes. The middle categories also represented increasingly more successful attempts at establishing a one-to-one correspondence between the variables to pattern recognition leading to recognition of a relationship between the variables. Middle school subjects exhibited behaviors mainly in the first four categories, ninth and tenth grade subjects overlapped with the middle school subjects and also overlapped with the eleventh and twelfth grade subjects in the middle categories, and the eleventh and twelfth grade subjects exhibited behaviors mainly in the last five categories.

The categories appeared to be valid with the three types of line graphs and the subject response patterns were the same on all the instruments. These response categories also showed a close fit with Piagetian concrete operational structures for single and

double seriation and with formal operational structures for proportional reasoning and correlational reasoning.

The implications of this research for science teaching are these. Teachers can now be aware of what logical reasoning students will bring to a graphing situation. Teachers will also be able to understand the reasons why students make certain mistakes when they make line graphs. Teachers will be able to make interventions that will not only help students make their graphs correctly but possibly will help students develop the logical reasoning to make their graphs correctly on future occasions.

Session D-15

THE DEVELOPMENT, VALIDATION AND ADMINISTRATION OF A CRITERION-REFERENCED SCIENCE BATTERY FOR GENERAL EDUCATION STUDENTS IN COSTA RICA

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ABSTRACT

The purpose of this study was twofold: a) to develop and validate criterion-referenced tests in order to measure science knowledge of students who finished the fifth grade as well as the ones who finished the three cycles of the General Education; b) to assess the performance of these tests with a national random sample of fourth, sixth, seventh and tenth-graders in 127 elementary and 43 public secondary schools in Costa Rica.

Sets of 16 to 20 behavioral objectives were specified in order to define a content domain to be measured by each test. These sets of objectives were selected after elementary and secondary science teachers in several regions of the country were consulted. The teachers gave their opinions based on the science program and their experience on which objectives represent the minimum science knowledge a student must have. At least ten items were constructed to match each objective. A panel of five science educators chose three out of ten items for each objective. Therefore, the fourth-grade test was composed of 48 items, the sixth-grade test of 42 items, and the seventh- and tenth-grade test of 60 items. The procedure employed to define the content domain and to develop and select items to measure the domain supported the content validity of the tests. Reliability was calculated using KR-21.

The instruments were administered to 1012 tenth-graders, 1130 sixth-graders, 794 seventh- and 449 tenth-graders who were enrolled in elementary and high schools chosen at random from the total of public schools in Costa Rica. Only two objectives were mastered by fourth-graders in a specific region and any other

objectives were mastered at any other grade levels. Norm-referenced analysis of the data using ANOVAS showed significant differences among regions and type of elementary and high schools. The tests are very useful for researchers and Science educators this being the first attempt to develop and validate C-R tests in Science for the Costa Rican Educational System.

Session B-16

RELATIONSHIPS OF ATTITUDE TOWARD SCIENCE AND FAMILY ENVIRONMENT

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ABSTRACT

This investigation was made on data gathered as a part of a larger longitudinal, multi-dimensional study that has as its goals the examination of the relationship between variables of the home, school and self as they relate to attitude toward and achievement in science. The purpose of this investigation was to look at the characteristics of family environment and determine the nature of the contribution of family environment to attitude toward science. The data collection took place in a large school district in North Carolina. The instruments were administered in the fall, winter and spring of the school year.

The two family oriented subscales were targeted for examination as regressors to the dependent variable of attitude toward science. One of these, the family science subscale included items to assess student perception of their family's science support. The other, called family general, consisted of items to assess student opinion of the quality of their family life. The population under study consisted of over 800 seventh grade students and over 1,400 tenth grade students. The students were from four randomly selected schools in the district and had been previously assigned to their ability-group tracks, which had three levels, by pre-existing local school guidelines.

The statistical design in this investigation was multiple linear regression using SAS procedure REG. The population was examined by ability group track, by grade and by time.

In the regression model developed, the probability level which indicated the relationship of the family science variable to

science attitude was highly significant (0.001 level). This was for all ability-group tracks at each grade level and over time for each grade level. The family general variable was found to be significant in its relationship to science attitude for Track 2 ability-groups at both grade levels and over time for the tenth grade, but not over time for the seventh grade. The seventh grade Track 2 probability at time 3 for the T-value was 0.0754.

Family environment is defined as being the interactions which take place between family members. They are reflected in the members' behaviors and attitudes in other places such as the school. The high degree of influence of the family on a student's schooling is generally established.

It can be concluded that there is a need for science education researchers to further examine the family environment variable, as previously defined, as a source of alterable variables. The positive enhancement of these family influences in a student's learning environment could improve attitudes toward science among adolescent students.

Session B-16

PRESERVICE TEACHERS' RETENTION OF CHANGED ATTITUDES TOWARD ENERGY CONSERVATION: COGNITIVE RESPONSE OR RECALL OF MESSAGE ARGUMENTS

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ABSTRACT

This investigation attempted to determine if subjects' cognitive responses to a persuasive communication are more highly correlated with attitude change than the recall of arguments presented in the communication. Subjects were exposed to a systematically designed persuasive communication and then tested for their retention of the arguments presented in the communication and cognitive responses. Attitude change was found to be significantly correlated with cognitive responses elicited immediately following the persuasive communication and cognitive responses recalled three weeks later. No significant correlation was found between the recall of communication arguments and attitude change. The results offer a plausible explanation of the contradictory findings reported in the science education literature regarding the dissipation of attitudes changed using persuasive communication.

Session B-16

THE EFFECT OF WRITTEN PERSUASIVE COMMUNICATION ON CHANGING ATTITUDES OF EGYPTIAN PRESERVICE BIOLOGY TEACHERS TOWARD TEACHING EVOLUTION

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ABSTRACT

The purpose of this study was to determine the effect of written persuasive communication on changing attitudes of Egyptian preservice biology teachers toward teaching evolution. The Pretest-Posttest Control Group Design was chosen as the design for this study. The subjects who participated in this study consisted of 154 volunteers (46 males and 108 females) enrolled at Biology Section in the College of Education, University of Tanta, Egypt during the academic year 1983-1984. The subjects were randomly divided into two equal treatment groups: 1) the experimental group (the persuasive communication group); and 2) the control group (the control communication group). Two different treatment materials were used as a part of this investigation: 1) the persuasive communication which consisted of a written message, printed information on the importance of teaching of evolution to secondary school students, and 2) the control communication which consisted of a written communication about air pollution. The Attitude Toward Teaching Evolution Scale was developed to be used in this study. This scale was administered as a pretest and posttest to assess attitude change. Analysis of covariance was used to analyze the data. The findings of this study indicated that there is a significant difference (at the .05 level) in the adjusted posttest mean scores between the experimental group and the control group. This difference was in favor of the experimental group. It was concluded that Egyptian preservice biology teachers who received the written persuasive communication had a positive change in their attitudes toward teaching evolution to secondary school students.

Session B-17

AN INQUIRY INTO THE PHENOMENON OF UNDERSTANDING ABSTRACT CONCEPTS

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ABSTRACT

In this study two methods were used: indepth review and synthesis of related literature and six pilot exploratory studies conducted by the author during the last decade.

This study was attempted to define abstract concepts, delineate the mental processes involved in abstraction and draw implications to curricula and instruction in science.

Session B-17

A PRELIMINARY REPORT ON THE EFFECTIVENESS OF A YEAR LONG INTERVENTION TO PROMOTE SCIENTIFIC LITERACY

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ABSTRACT

The purpose of this study was to develop a ninth grade curriculum that taught the skills of scientific literacy, moved students from concrete to formal thought, and to determine whether variables such as personality, field dependence/independence and attitude are mitigating factors in the acquisition of reasoning skills. The selection of materials and their sequencing was based on Piagetian theory. The definition of scientific literacy was taken from Arons' description in the spring 1983 issue of Daedalus. The study was conducted in an urban catholic high school. There were 250 students in the study randomly assigned to three teachers who taught the course. Students received generic instruction on the skills of making observations and inferences, measuring, classifying, frames of reference, spatial ability, ratios and proportions, making combinations, controlling variables, hypothesis testing, logic and understanding scientific models. Content was selected to bring the student to an understanding of specific scientific models. Students were also tested on their ability to transfer these skills to content areas and own their mastery of content. Seventy students were chosen at random to be clinically tested for cognitive level using Piagetian instruments and the embedded figures test. Preliminary analysis indicates that skill acquisition was facilitated by instruction. Skill acquisition was more difficult than was anticipated for ninth grade students. The course also made a significant impact on students' attitude toward science. An issue of major importance was the assignment of grades because of the developmental underpinnings of the course. Another issue of concern was the students' and parents' attitude to a process based rather than a content based course.

Session B-17

COGNITIVE PREFERENCES AND SCIENCE TEACHING BEHAVIOR

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ABSTRACT

The purpose of this exploratory study was to search for possible relationships between science teachers' observed classroom behaviors and their cognitive preferences as measured by a written instrument.

Fifty-six teachers in grades five through eight were observed teaching science lessons. Each teacher chose three lessons for the study. A behavior coding system was used by trained observers. Behavior codes were analyzed on an Apple II microcomputer. Anecdotal records were also kept. The teachers completed the Science Cognitive Preference Inventory (SCPI) which measures preferences for recall, principles, applications, and questioning. Three groups of teachers were formed: one highest in questioning, one lowest in questioning, and one with indistinct cognitive preferences.

Major conclusions were:

1. The three groups of teachers classified on the basis of their cognitive preference tests were found to exhibit different teaching styles significant at 0.053.

2. Correlations between particular behaviors increased when data from teachers with only distinct preference scores were used, indicating that teachers with distinct preference scores may also have more distinct teaching styles.

3. The results of anecdotal records lent support to the cognitive preference construct.

4. The results of intercorrelations, factor analysis, and score patterns indicated a lack of discrimination between the recall and principle preferences. This lack of discrimination may call into question the traditional definitions of the modes, but not the entire construct

for which support was found, especially in the area of preference for questioning.

Session E-17

A STUDY OF STUDENT ATTITUDES TOWARD SCIENCE-TECHNOLOGY-SOCIETY RESULTING FROM VISISTATION TO A SCIENCE-TECHNOLOGY MUSEUM

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ABSTRACT

The problem of the study was to determine if visitation to a specialized science-technology museum affected student attitudes toward Science-Technology-Society (STS); and if so, in what ways teacher use of planned instructional strategies for the museum, and prior student experience with STS, correlated with these attitude changes.

The null hypothesis of the study was that there would be no significant differences in attitude toward STS between students who had visited science-technology museums and students who had not visited such museums. Three subordinate hypotheses were also tested, aimed directly at those students who had visited science-technology museums. These hypotheses dealt with the extent to which teachers' use of the museums was planned and how this planning related to student attitudes toward STS.

A nonequivalent control group design utilizing pretests and posttests was used. Subjects were in intact groups with unequal n's. Subjects included Kansas students from grades 6-8. Prior to pretesting, all subject were given the Student STS Questionnaire to determine prior exposure to STS and to establish socioeconomic status. All subjects were pretested using the Scientific Attitudes Inventory (SAI). Pretesting occurred during the fall semester and prior to visitation to museums. Three weeks later, all subjects were again given the SAI, this time as the posttest. During pretesting, teachers were given the Teacher STS Questionnaire to determine prior use of STS in the classroom and to determine the extent of instructional planning for museum visitation. This latter component served only for those teachers whose students visited museums. Nonvisiting teachers did not receive questionnaires including this component. Teachers whose classes visited museums were interviewed at the time of

posttesting to further delineate instructional strategies used with museums.

Analysis of covariance, using pretest scores as the covariate, was employed on a 2 X 2 matrix comparing prior student STS exposure and museum visitation. A second analysis of covariance was utilized on a 2 X 3 matrix comparing prior student STS exposure and levels of teacher instructional strategy employed in museums. Further analysis was done comparing student attitude changes and various demographics of subjects.

Session B-17

IDENTIFYING STUDENTS' DIFFICULTIES IN UNDERSTANDING CONCEPTS PERTAINING TO CELL WATER RELATIONS: AN EXPLORATORY STUDY

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ABSTRACT

The study attempts to identify students' conceptual difficulties in understanding concepts and processes associated with cell water relations (e.g., osmosis) and to find out possible reasons for these difficulties. This area was chosen because osmosis is a key concept for many important life processes and consequently it is studied repeatedly in schools. Yet, experience and previous research has indicated that many students have had conceptual difficulties in this area, perhaps because of the dependence on basic concepts in physics and chemistry (e.g., diffusion, solubility, particulate nature of matter, potential) which teachers may wrongly assume that students have mastered in their previous studies. Three research strategies were used: content analysis of commonly used textbooks, three paper and pencil questionnaires featuring 72 true/false items and individual interviews based on two demonstration experiments. One hundred forty-two students in grades 9, 10, 11 participated. The main findings were:

1. Certain concepts are presented by the textbooks in ways which may confuse students.

2. Certain textbooks, e.g., the BSCS texts, hardly mention osmosis.

3. In all questionnaires there were no differences between the different grade levels.

4. Concepts which appeared to raise difficulties were osmosis, osmotic pressure, potential.

5. Serious misconceptions exist with regard to basic concepts such as solutions, solubility, particulate nature of matter and molecular movement. These misconceptions are partially responsible for difficulties in understanding osmsotic relations.

6. Teleology and anthropomorphism are widely used as if they provice causal explanations.

7. Students often use textbook definitions of osmosis and diffusion without fully understanding these concepts.

This exploratory study points at the need for large scale comprehensive research which can use the same strategies in order to substantiate and extend the findings. Subsequently, instructional materials and strategies should be designed to reach better comprehension of the concepts and processes associated with cell water relations.

Session B-17

HOW DOES THE USE OF NEWSDAY'S SCIENCE EDUCATION SERIES PROGRAM AFFECT SELECTED NINTH GRADE STUDENTS' COMPREHENSION OF SCIENCE READING MATERIAL?

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ABSTRACT

Reading is a communication process that is crucial to students in all learning areas, but especially in science. Printed text materials are the most widely used teacher aids in the science classroom. Whether working individually or in groups, students are constantly referring to textbooks, articles, handouts, and laboratory manuals. If used properly, such material can facilitate student achievement. It is imperative that students comprehend science reading material.

The purpose of the present study was to determine how the use of Newsday's Science Education Series Program affected selected ninth grade students' comprehension of science reading material.

The students involved in the study were 136 New York City ninth graders, divided into six classes. Three classes consisted of students with standardized reading and mathematics scores at least two years above grade level, while three classes consisted of students with standardized reading and mathematics scores on grade level. All students came from Queens, New York. Some walked to school while others used public transportation. They were of a middle socio-economic background. The sample was about one-half male and one-half female.

The Degrees of Reading Power was administered to the sample in March 1984. The instrument assesses a student's ability to comprehend prose material written at various levels of difficulty,

has a psycholinguistic orientation, and resembles a modified Cloze format.

One class (n=19) with students' standardized reading and mathematics scores at least two years above grade level, and one class (n=24) with students' standardized scores on grade level, followed the Newsday Science Education Series Program format. Once each week, for ten weeks, a newspaper science article was selected and used according to Newsday's directions.

One class (n=29) with students' standardized reading and mathematics scores at least two years above grade level, and one class (n=21) with students' standardized scores on grade level, read the same newspaper science articles as the first two classes cited, but the science teacher did not follow the Newsday format. The students read the science articles, discussed the content, and answered questions pertaining to the articles. The science teacher never saw the Newsday Program.

Finally, one class (n=21) with students' standarized reading and mathematics scores at least two years above grade level, and one class (n=22) with students' standardized scores on grade level, did not use Newsday's format and did not read any newspaper science articles. The science teacher used the newspaper science article the other two groups (four classes) had read, but only to teach the article's content. The teacher never saw the Newsday Program. The three science teachers involved in the study had similar professional backgrounds.

After ten weeks, the Degrees of Reading Power test was administered again. Correlated t-tests were used to evaluate the null hypothesis, "There is no change in selected ninth grade students' comprehension of science reading material, whether the students used the Newsday Science Education Series Program format, newspaper science articles alone, or were taught only content from specific newspaper science articles."

Students with standardized reading and mathematics scores at least two years above grade level did not show a statistically significant difference between pre-test and post-test Degrees of Reading Power scores when taught using Newsday's Program, or when taught newspaper science articles' content without the article. The null hypothesis must be accepted. But, when taught using the news paper science articles alone, there was a significant increase in the post-test scores at the .01 level. The null hypothesis must be rejected.

Students with standardized scores on grade level who were taught using newspaper science articles alone, or who were taught newspaper science articles' content alone did not show a statistically significant difference between pre-test and post-test Degrees of Reading Power scores. The null hypothesis must be accepted. But, when taught using Newsday's Program, there was a significant increase in the post-test scores at the .05 level. The null hypothesis must be rejected.

Session E-17

THE PORTRAYAL OF MINORITIES AND WOMEN IN SELECTED ELEMENTARY SCIENCE SERIES

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ABSTRACT

The purpose of this study was to determine the quantitative and qualitative portrayal of females and minorities in the illustrations of seven contemporary elementary science textbook series. An evaluation instrument was devised to determine the current status of the targeted groups. Illustrations were evaluated on the basis of minority/nonminority and male/female representation. The activity and assumed role of the individuals were also tabulated. A total of 5,965 human illustrations were evaluated. The results reveal that the female children group is represented with greater frequency than are other child groups. Minority children are represented less often than nonminority children and female and minority adults are depicted less often than nonminority male adults. The textbooks evaluated in this study display science positively for most societal groups. However, minorities are underrepresented and illustrated in a limited number of career roles. Implications and suggestions for teachers, supervisors, and teacher educators are provided.

Session B-17

THE VIEW OF SCIENTIFIC LITERACY AS PRESENTED IN EARTH SCIENCE TEXTBOOKS

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ABSTRACT

The need for scientific literacy among the nation's citizens has long been recognized. A major re-emphasis on the issue which began in the mid-1960s appears to be gaining attention in the 1980s. A question that could logically be raised then centers on why, after two decades of emphasis, has the goal of scientific literacy not been reached.

This study addresses that question by examining earth science textbooks published for middle school/junior high level students to determine whether the aspects of scientific litieracy are present and at what level each aspect is represented. Textbooks appear to be the message and the vehicle of the curriculum in sciences. Therefore, students who learn science from textbooks which do not adequately reflect a balanced view of science necessary to promote scientific literacy cannot be expected to become scientifically literate citizens.

Scientific literacy has been defined and described, often in detail, during the past two decades. It has been noted that everything that has anything to do with science has become associated with scientific literacy. A model of scientific literacy was synthesized from these past studies. The four aspects of scientific literacy agreed upon by investigators and included in the model are (1) Basic Knowledge of Science, (2) Investigative Nature of Science, (3) Thinking Processes of Science, and (4) Interaction of Science, Technology and Society.

In order to determine whether textbooks reflect the goal of scientific literacy, an instrument was developed with which textbooks could be analyzed. The four aspects of scientific literacy formed the basis of the instrument; content analysis provided the technique. Science educators, using the instrument, analyzed the five earth science textbooks adopted by the State of

Texas for the academic years 1983-1989. The results of the analysis were analyzed to determine the level of inclusion in general of each aspect of scientific literacy. The results indicated that earth science textbooks heavily favor the basic knowledge aspect of science and thus do not reflect the goal of scientific literacy.

Since the textbooks cannot be considered a source of scientific literacy, the implications for science education are clear. (1) Both inservice and preservice teachers must be made aware of the nature of the textbook and its impact in the classroom. (2) Additional curricula materials must be developed to supplement the textbooks. (3) The instrument developed during this study can be used by teachers faced with textbook adoption decisions.

Session B-17

PRESERVICE SCIENCE EDUCATION - WHAT AFFECT METHODS CLASSES?

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ABSTRACT

Five years of data related to teachers' perceptions of learning and knowledge were analyzed to ascertain whether differences existed between preservice elementary and secondary science students. The data were generated from a questionnaire derived from assumptions about learning and knowledge. The assumptions speak to five areas of learning: motivation, conditions of learning, social learning, intellectual development and evaluation. Knowledge assumptions comprise a sixth area.

The data were analyzed using a Chi Square statistic with the probability set at the .05 level of significance with the number of cases (n) being 435. There were no significant differences in prescores for either elementary undergraduate and graduate students or secondary undergraduate students. No significant differences occurred with post scores between undergraduate and graduate elementary education students. However, significant differences occurred between undergraduate elementary and secondary students in the areas of assumptions about motivation, conditions of learning and knowledge requirements of school children.

The study supports the NSTA recommendations for certification of elementary and middle/junior high science teachers. Also, there is some indication that inservice and preservice education need to follow varying paths.

Session B-17

AN EVALUATION OF THE ELEMENTARY SCIENCE METHODS CLASSES AND OTHER METHODS COURSES AS PERCEIVED BY BOTH PRESERVICE EDUCATION TEACHERS AND CLASSROOM TEACHERS

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ABSTRACT

The problem of this study was to determine the effectiveness of the science methods course as compared to other methods courses in elementary education at Indiana University Southeast. The survey was administered for three consecutive semesters to both classroom teachers and preservice teachers.

After administering the questionnaire to both the classroom teachers and preservice teachers, percentages for each question were analyzed. When means and standard deviations were analyzed, no significant differences were found. This supports that both the experienced classroom teachers and the preservice teachers were in agreement on the preparation of the preservice teachers.

Session E-17

ATTITUDES OF UNIVERSITY CANDIDATES TOWARDS LEARNING ACTIVITIES AIMED AT PREPARING THEM FOR SCIENCE STUDIES

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ABSTRACT

Students' attitudes, expectations and opinions about learning activities were investigated before and after one year of science studies in the Preacademic School (PAS) of the Hebrew University, Jerusalem. A 5-part questionnaire was pre and post administered to 150 PAS students (70% of whom were classified as academically disadvantaged according to socioeconomic criteria) during the years 1978-1980.

The main finding showed that prospective science students expect that in their learning preparation program, study skills activities, such as efficient scientific reading, essay writing, note taking, data analysis or orientation in the scientific library, should play an important role beyond that of merely subject matter teaching. These learning skills were considered by students to have a significantly greater influence on future success in university studies than factors like talent, hard work or socioeconomic origin. However, students perceived their competence with regard to many learning skills activities to be fairly low.

They also felt that the learning skills instruction actually offered at the PAS was far below what they would have liked it to be. Such a dissatisfaction was not found in relation to traditional subject matter oriented activities, some of which were even judged to be superfluous.

It was concluded that learning skills should play an important role in remedial program for disadvantaged students either in preacademic programs, or in upper classes of secondary

school, or in the first year in college. An example of the potential and actual contribution of such a study skill program to improved achievement is briefly discussed.

Session B-17

THE ROLE OF PRE-PLANNING CURRICULUM EVALUATION IN SCIENCE EDUCATION

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ABSTRACT

A new dimension designed as Pre-Planning Evaluation (PPE) is proposed as complementary to the two currently used forms of evalution namely formative and summative. The purpose of PPE is to provide data base to curriculum development deliberations in order to assist in decision making and guard against neglect of important issues. PPE is certainly essential when no pertinent evaluation data exist, but it was found to be useful even in cases when evaluation data of previous generations of curricula do exist.

Three case studies are presented to illustrate the nature and potential of PPE: the biology curriculum in Israel, the high school biology curriculum in Australia and the electricity curriculum in technical high school in Israel. Examples of findings and conclusions of PPE studies are:

1. In elementary grades the needs of individual students should take precedence over the demands of subject matter and society.

2. The best way of meeting the needs and matching the capability of elementary school students is to study macroscopic organisms (plants and animals) and to become familiar with phenomena in the immediate environment.

3. Quantitative statistical treatment of data should be done mainly in the senior high school.

4. More emphasis should be given to human biology and its applications.

5. Narrative of inquiry is an appropriate and desirable way to presenting biological reading materials to students of all ages.

6. Continuous short time revision of laboratory manuals is very important.

7. Information and techniques in electricity becomes obsolete in 5 to 13 years. Hence, much of what students will have to know and do on their job will be different from what they have studied in school. How can students be prepared to cope with rapid changes in the future?

The last case study, namely that dealing with electricity is the most comprehensive and involves data collection from eleven different relevant populations as well as analysis of variety of pertinent document. A format of data presentation which facilitates comprehension and utilization of PPE information in curriculum deliberations is presented as well. There is evidence that the provision of PPE data to curriculum planners indeed results in better and more comprehensive deliberations with balanced attention given to subject matter, students, teachers and society.

Session B-17

ANXIETY LEVELS OF STUDENTS TAKING REQUIRED COLLEGE SCIENCE COURSES

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ABSTRACT

The purpose of the study is to measure initial anxiety levels and examine the science and math backgrounds of all college students taking science courses to complete their science requirement in the following disciplines: biology, chemistry, geology, physics and psychology.

Data were collected in September 1984 from about 760 students. The data are now being placed on cards to be optically scanned and entered into the computer to be processed using SPSS. This process will be completed by early December and the analyses will be done in January.

This will provide actual data on initial anxiety levels in various disciplines and will include analysis of scores for males and females and choice of academic major. It is "base line data."

Session B-17

INVESTIGATION OF PREENTRY PLANETARIUM ACTIVITIES: ADVANCE ORGANIZERS VERSUS PEGMNEMONIC DEVICES

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ABSTRACT

The purpose of this study was to compare the effects of advance organizers and mnemonic instruction in lessons presented at a planetarium. The comparisons of treatments were made at three student achievement levels in order to compare interaction effects.

The study examined effects of the mediators on learning in the planetarium classroom. A related question posed by the study asked if preentry instruction increases effectiveness of the planetarium instruction.

The scheme of the investigation was a nonrandomized posttest design with tenth grade students in an intact school system as subjects of the study.

Nine class sections including 233 students participated in the study. Three class sections were randomly assigned to each treatment with one class section from each achievement level receiving each treatment. The control groups were not involved in any preentry planetarium lessons. The other treatment groups included groups instructed through advance organizers before the planetarium instruction and groups instructed in the use of mnemonic device use before the planetarium instruction.

Reliability was examined in the posttest through the Spearman Brown formula and the items were compared through use of the split halves formula. A committee of Earth Science instructors in the school system examined the validity of the instrument.

The analysis of variance conducted on the posttest scores indicated significant results at the .05 level in the case of advance organizer treatment groups. The Scheffe formula was used for further comparisons of the data. The Duncan method also

indicated significant effectiveness of advance organizers upon the effectiveness of the instruction.

The mnemonic strategy instruction was found to significantly improve learning performance of the EMR classes who were the lowest level of student achievers in the study. Perhaps this indicates that a majority of students build their own mnemonic strategies.

The investigation produced data that indicated that preentry activities do have significant positive effects on planetarium lessons.

Session B-19

THE EFFECTS OF PROBLEM FORMAT, NUMBER OF INDEPENDENT VARIABLES, AND THEIR INTERACTION ON STUDENT PERFORMANCE ON A CONTROL OF VARIABLES REASONING PROBLEM

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ABSTRACT

This study was designed to investigate the effects of problem format and the number of variables in the problem on the responses of students to a control of variables reasoning task. The Bending Rods problem was used. A 4 X 2 factorial research design with four levels of the number of variables and two formats (essay and multiple choice) was set up for the investigation. Five hundred forty-eight eighth graders in 24 science classes in a suburban public school district northwest of Chicago participated in the study. Students were administered the Bending Rods problem in groups in their science classes. Each classroom was randomly assigned to a cell in the research design. Initial analysis indicated that four levels of the number of variables in the problem should be pooled to two levels. This was accomplished by combining the level on each extreme with its adjacent level. Analysis of variance indicated that: 1) task format had no effect on subject's scores; 2) the 2-, 3- variable forms together were significantly less difficult for students than were the 4-, 5-variable forms together; and 3) the differences between subjects' mean scores on the 2-, 3- variable essay versions and the 4-, 5-variable essay versions are significantly greater than the mean scores of corresponding multiple choice versions of the task, which exhibit rather uniform, intermediate scores. Discussion focuses on interpretations that include: 1) task demands on working memory; 2) Pascual-Leone's M-energy; and 3) the use of synthesis and exclusion strategies in solving essay and multiple choice tasks, respectively. Implications for science teachers are set forth in view of these discussion points and their relevance to test construction and classroom assessment of learning objectives in science.

Session B-19

THE ROLE OF PRACTICE IN INVENTING THE RULE FOR SOLVING LOGICAL SYLLOGISMS

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ABSTRACT

Science educators have recognized that some degree of logical reasoning is required for success in science. To be able to predict success in science subjects, students have been evaluated for their logical abilities by various tasks, one of which is the logical syllogism. The results of these investigations have led the investigators to conclude that most science students are illogical. The evaluating instruments were constructed with symbols (e.g., size and shape) in order to follow the "hypothetical-mathematical" model of Piaget. More recent studies have demonstrated that success with the syllogisms is appreciably greater when the subject matter is familiar, and that skills demonstrated on these tasks are transferable to other contexts, also familiar in content. These studies also suggested that some degree of generalizability can be expected to occur, and indeed was realized by an increase in proficiency with the symbolic-content conditional syllogism.

Based on the results of these investigations, an experiment was conducted to see whether practice can enhance the transferability of skills from familiar-content tasks to symbolic content tasks for both the conditional (if, then) and the inclusive disjunction (or, or both) connectives. Symbolic-content tasks were administered just after the beginning of the semester, and near the end of the semester. Familiar-content tasks were administered just after the beginning of the semester, at mid-semester, and again near the end of the semester. Subjects were students enrolled in an introductory biology course for non-science majors. Subjects received no feedback regarding their success on the tasks, nor were they furnished with the appropriate answers. Therefore, any improvement in proficiency would be due to a direct transfer of skills. The results were dramatic. There was a definite significant improvement in proficiency with symbolic-content tasks for both operators. In fact for the conditional syllogism, there was virtually no difference in proficiency between familiar-content and symbolic content on the final set of tests. Some difference still exists for the inclusive disjunction syllogism due to type of content. However, the increase in success between the pre- and posttests indicate that a highly significant increase in proficiency occurred. This

experiment dramatically demonstrates that even minimal practice with familiar-content syllogism can lead subjects to invent the rules necessary for solving symbolic-content syllogisms.

The implications for science education are tremendous. If we consider logical aptitude a requirement for success in science, then we are bound to encourage the development of these skills if we want our students to be successful. By incorporating everyday situations or subject matter into logical problems, and by providing these materials for practice, eventually we could expect the development of logical thought of the kind necessary to scientific inquiry.

Session B-19

A STUDY OF DIFFERENTIAL PROBLEM-SOLVING BEHAVIORS IN PROCESSING A SCIENCE TEXT PASSAGE

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ABSTRACT

This study gathered protocol data related to how students process information obtained by reading a passage related to inertial reference frames. Two groups of tenth grade students, one of which consisted of students identified as potential National Merit Scholars, and another which consisted of students who were enrolled in Biology I in a large, middle SES high school read a science text passage and then answered a set of six questions requiring that they apply the new material in novel situations. Raw and weighted test score data and reading times were compared, and as expected, the academically talented students achieved higher raw and weighted scores; their reading times were also longer. The focus of the study, however, was the analysis of the tape recorded interview data about how they processed each question. Interviews were conducted by the investigators in one-on-one situations, and verbatim transcripts of the interviews were made. Test questions were specifically designed to reveal problem solving strategies. The academically talented students were more verbal, more methodical in comparing questions to the passage, and more likely to relate questions or parts of the text to their own past experiences. The average students often looked for a literal match between the questions and the text, and were much more likely to answer questions based on previously held "naive theories," which sometimes were in direct conflict with the text material. The results of the study suggest that caution is needed in assuming that students will learn effectively from text presentations of new concepts.

Session B-20

FACTORS RELATED TO DECISION-MAKING

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ABSTRACT

Decision-making is very similar to problem solving in regards to the mental skills involved. Decision-making involves values and ethical considerations that problem solving situations may or may not include. Little attention is paid to curriculum development or instructional procedures for teaching decision-making skills to children.

The decision-making process can be broken down into a series of processes. They include the identification of the problem, the generation of alternative solutions, the recognition of the consequences of the alternatives and the selection of a solution from the alternatives.

It is suggested that there is a strong and direct relationship betweeen the number of alternatives a child can generate and the quality of the decision. Therefore, the component of the decision-making process selected for this research is the ability of children to generate a variety of alternative solutions in a decision-making situation. After the critical factors of the environment related to this skill are identified, then future efforts will be focused on the factors related to the quality of the decision made.

Session B-21

TEACHERS' PERCEPTIONS OF MAINSTREAMING IN AN INQUIRY ORIENTED ELEMENTARY SCIENCE PROGRAM

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ABSTRACT

In order to obtain elementary classroom teachers's views on the effectiveness with which handicapped children can be integrated into the regular classroom for activity centered science, a survey was conducted in a school district using the Science Curriculum Improvement Study (SCIS). The following questions were addressed through the survey of the SCIS teachers:

1. Relative to other subject areas, how do teachers rank science on the ease with which handicapped students can be effectively integrated for instruction?

2. Compared to other subject areas, what do teachers view as the greatest advantages and disadvantages of mainstreaming in elementary science?

3. What are the teachers' views of how handicapped and non-handicapped students feel about elementary science?

4. What are the teachers' views about teaching science to both handicapped and non-handicapped children and about teaching handicapped children generally?

The sample was obtained by sending a survey instrument to an accessible population of second, fourth, and sixth grade SCIS teachers in a metropolitan school district in Kentucky. Of the 269 teachers receiving the instrument, 146, or 54%, returned a usable set of responses. Results indicated a strong preference for science over the other subject areas ranked. The flexible activity orientation of the SCIS program seemed central to the perceived advantages, while the language skill requirements and the difficulty in concepts and terminology were the major disadvantages identified. The feelings of adequacy for teaching handicapped children were judged to be less desirable than the positive feelings with which the task is approached. While the

results of the survey cannot be generalized to elementary level science generally, or even to the national sample of SCIS teachers, the findings do suggest that SCIS can work well for handicapped children. Because of the potential benefits of science for the handicapped, replication of the survey in school systems using SCIS and other science programs seems warranted and is recommended.

Session B-21

A COMPARISON OF THE REASONING ABILITY OF GIFTED AND MAINSTREAMED STUDENTS

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ABSTRACT

A sample of 217 students from an elementary school Gifted and Talented program with an emphasis on science were compared to a group of older mainstreamed students, and found to be accelerated by two to three grade levels.

Measures used in this assessment were a battery of Piagetian tasks (controlling variables, combinations and probability), a measure of propositional reasoning ability (Propositional Reasoning Test) and a variation of the four-card hypothesis testing task. The differential success of the G&T students over the comparison group suggests that they are truly gifted in regard to very basic reasoning skills.

The criteria for inclusion in such programs vary from case to case, and are rarely well defined. Standardized aptitude tests may be appropriate for an academically oriented acceleration program, but probably are not for local pullout enrichment programs. A more general battery of reasoning tasks, such as those used in this study, should be included in the selection of students for such G&T programs.

Session B-21

TEACHING SCIENCE TO GIFTED CHILDREN: THE MODEL AND THE MESSAGE

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ABSTRACT

This paper is concerned with the kind of messages about science conveyed to 23 young gifted children during the utilization of a particular teaching model. Five science lessons were analyzed by applying a newly developed scheme to the classroom interactions--both discourse and science activities. The scheme enables one to identify three views about science: two polar views of sensationalism and formalism, and a rational, balanced via media view. The clues of the scheme also reveal how these views are being conveyed to the pupils. The pedagogy in this gifted class involved the application, by a "master" teacher, of the Calvin Taylor Multiple Talent Approach--a teaching model which focuses on developing six talent areas in order to enhance the inquiry skills of gifted and talented children. The talent areas include creativity and decision-making talents, planning and forecasting talents, communication talent and thinking ability.

Recognizing that gifted children have more general knowledge and more varied experiences than pupils not so identified, it was hypothesized that application of the Taylor model would facilitate the children's acquisition of a via media view about science. This was not borne out. Analysis revealed that only two of the six inquiry skills were being developed during the lessons and in such a way as to convey a sensationalist view of science more often than a via media view. The results of this study could have important implications for teaching science to gifted children and for planning and implementing new science curricula in these classes.

Session C-1

STUDENT CONCEPTIONS OF NATURAL SELECTION AND ITS ROLE IN EVOLUTION

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ABSTRACT

Students in a college non-majors' biology course were given pretests and posttests designed to assess their conceptions of natural selection and its role in the evolutionary process. Students were also asked whether they believed the theory of evolution to be true, and they were asked to describe previous coursework in biology.

Analysis of test results revealed three important respects in which most students had misconceptions about the process of natural selection:

1. Origin and survival of new traits in populations. Biologists recognize that two distinct processes, fundamentally different in cause and effect, affect traits exhibited by populations. New traits originate due to random changes in genetic material, then survive or disappear due to selection by environmental factors. In contrast, students generally recognized only a single global change process, attributing changes in species characteristics to necessity (a trait was needed for survival), to use or disuse of organs, or to adaptation by individuals. In general, students made no distinction between mechanisms leading to the appearance of a trait and mechanisms leading to its survival within a population.

2. The role of variation within a population. Biologists recognize that populations evolve because some individual members of a population possess a reproductive advantage over other individual members. Most students, however, saw evolution as a process that molds or shapes the species as a whole.

3. Evolution as the changing proportion of individuals with discrete traits. Biologists recognize that new traits arise through discrete changes involving individual organisms. Those traits then gradually become established in a population. Students, however, attributed this gradual or progressive quality to changes in the traits themselves, describing the traits as slowly improving or deteriorating from one generation to the next.

Pretests indicated that virtually none of the students understood any of the three key conceptions described above at the beginning of the course. This was true even though 88% of the students had taken at least one year of biology before beginning the course, and 37% had taken two or more years. There was no relationship between pretest performance and previous biology coursework. These results indicate that most presently used methods for teaching about natural selection are ineffective for this population.

Student performance was improved by the end of the course, which included special activities designed to help students overcome their misconceptions. The three biological conceptions described above were understood by 53%, 57% and 63% of the students, respectively.

The course did not substantially alter student beliefs about the truthfulness of evolution. Fifty-three percent of the students taking the pretest believed the theory of evolution to be true, 12% false, and 37% were undecided. Posttest percentages were similar (59% true, 18% false, 24% undecided). There was no relationship between student understanding of natural selection and beliefs about the truthfulness of evolution, and an improved understanding of natural selection did not generally lead to increased acceptance of evolutionary theory. Student beliefs about the truthfulness of evolution (both positive and negative) generally seem to be based more on religious or metaphysical commitments than on an analysis of scientific evidence.

Session C-1

PHILOSOPHICAL RESEARCH ON THE PROBLEM OF THE UNLEARNING OF INCORRECT SCIENCE CONCEPTS

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ABSTRACT

Philosophical research methods were applied to the problem of unlearning incorrect science concepts to clarify basic questions for which other forms of research may be indicated. Research on children's thinking about science has indicated that students do not enter their first science studies ignorant of science. Rather, they may hold quite sophisticated and imaginative ideas about science. Those based on sound scientific information constitute a basis for further science education. Those based on intuitive misconceptions, naive inferences, incorrect logic, and so forth may be inadequate, incorrect, or otherwise unacceptable. Research has further indicated that, because such misconceptions may be based on purposive thought, meaningful experiences, or authoritative non-science sources, students may hold on to certain misconceptions despite subsequent science instruction. Assuming that the retention of such prior notions precludes subsequent learning of "correct" science concepts, it is in the interest of science education to help students unlearn and replace them.

The purpose of this research was to generate ideas about ways science teachers might help students recognize and unlearn erroneous notions and replace them with sound new science concepts without lessening students' intellectual self-confidence or otherwise alienating their receptivitiy to new science learning. Piaget's constructivist theory of cognition and Ausubel's theory of meaningful learning were accepted as credible bases for philosophical speculation about ways science teachers may create sufficient cognitive dissonance to help students recognize and replace erroneous notions of science with meaningful new knowledge.

Philosophical analysis of common misconceptions among science students revealed an apparent similarity with certain outdated science concepts. A review of research in the history of ancient, medieval, and modern science confirmed several once valid but now outdated or rejected scientific concepts--some of Aristotle's and Galileo's ideas about motion, for

instance--similar to some of the common misconceptions held by students today.

Speculative philosophical examination of those similarities produced evidence that the systematic inclusion of the history of science in science teaching, specifically the history of the development of those major concepts about which common misconceptions exist today, could help students recognize and appreciate the inadequacies of their own incorrect ideas. Learning that some of their own ideas were once held to be correct by outstanding scientists should help students maintain their intellectual self-confidence as they are introduced to the findings of later scientists who found the once acceptable ideas inadequate, and why. Accommodation of new ideas in this manner could produce unlearning and replacement of old ideas with new science learning, increase the awareness of the nature of the scientific enterprise, and create a positive attitude toward science. These conclusions justified a recommendation for experimental investigations to assess the effectiveness of the teaching of the history of science for creating sufficient cognitive disequilibrium to help students to unlearn incorrect science concepts.

Session C-1

DIAGNOSTIC TESTS TO EVALUATE STUDENTS' MISCONCEPTIONS IN SCIENCE

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ABSTRACT

Since the beginning of the decade, there has been a growing interest in students' misconceptions in science. The usual means for obtaining information about student misconceptions has been through individual student interviews on specific science topics using a variety of formats. One pertinent criticism of this means of collecting information is its lack of direct utility to the classroom teacher.

One way to more easily identify misconceptions of a group of students taught by a teacher is to use a pencil and paper multiple choice diagnostic test which has items specifically designed to identify conceptual misconceptions and misunderstandings. This paper describes the development of such diagnostic tests and illustrates their use in identifying misconceptions in the students' understanding of the chemistry topic, covalent bonding, and the biology topics, photosynthesis and respiration.

Session C-2

VALIDITY CONSIDERATIONS FOR THE STUDY OF FORMAL REASONING ABILITY AND INTEGRATED SCIENCE PROCESS SKILLS

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ABSTRACT

Recently a number of studies have reported a high correlation between the supposedly separate traits described as integrated science process skills and formal reasoning ability. The implication has been that these two constructs are different but related. Implications have been made that a treatment to enhance one trait might influence the other as a result of some cause-effect relationship.

It would seem reasonable to consider whether these constructs are separate traits, or perhaps manifestations of some third trait such as general intellect. Research directions would be altered by this finding.

This study measured these two attributes using different instruments in order to assess their discriminant and convergent validity. Results indicated that the two traits share more variance than expected, and that they may not comprise distinctly different traits.

Session C-2

THE EFFECTS OF TEACHING LOGICAL REASONING UPON STUDENTS' CRITICAL THINKING AND SCIENCE ACHIEVEMENT

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ABSTRACT

One of the goals of science education has been to develop scientifically literate and concerned individuals with a high competence for rational thought and action. Science by its very nature is a logical discipline that requires certain rational thinking skills to solve problems.

In a rapidly changing society and scientific society, it is essential for individuals to think rationally and critically. The educational environment is the logical place to foster the development of rational and critical thought in science, and particularly in geology. Currently the educational system does not provide a specific program in geology designed to assist student growth in rational and critical thought. In order to develop such a program, a determination must first be made of the appropriate intellectual tool, namely logic, to be integrated directly into a course of geological study. Further a determination must also be made of the appropriate methodologies/strategies needed to assist teachers in actualizing this growth in their students.

This study explores the development of a geological course based on rational and critical thinking. The course incorporates logic into a geology course designed for nonscience majors. This study assesses its usefulness in not only increasing achievement in geology but also increasing critical thinking.

The data were analyzed using a multivariate analysis of covariance (MANCOVA). The results, including post hoc conclusions and implications, will be discussed during the presentation.

Session C-2

THE DEVELOPMENT OF STUDENTS' LOGICAL THINKING ABILITIES IN A PHILIPPINE SECONDARY SCHOOL

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ABSTRACT

The purpose of this investigation was to measure the development of Filipino secondary school students' logical thinking abilities and to determine if this development was similar for both males and females across all four years of schooling. The available population consisted of secondary school students at the Marikina Institute of Science and Technology in Marikina, Metro Manila, Philippines. Fifty students were randomly sampled from each of the four years of high school and administered the Group Assessment of Logical Thinking (GALT). Preliminary descriptive analysis shows an overall trend of increasing logical thinking ability from the first through fourth year. Males scored higher than females at all grade levels, with the range between group means increasing with each successive year of high school. Gender differences were not evident on each item at each grade level. For example, on an item measuring combinatorial logic, differences between groups in the second year of high school did not show up in the comparisons between groups in the fourth year. These results correspond with findings of similar studies conducted in the United States and have implications for both American and Philippine science educators.

Session C-3

WRITING AS A PROCESS IN A UNIVERSITY PHYSICAL SCIENCE CLASS

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ABSTRACT

Writing in general is purported to be an all-important, most neglected area in education, especially in the area of teaching science. Several recognized authorities in the field of writing advocate that writing be taught in all of the disciplines as well as English. The teaching of writing as "a process" rather than a "product" is also being suggested by writing authorities and funded projects.

This study was conducted to determine the effect of writing as a "process" rather than a "product" on the writing competency of students in a university Physical Science for Elementary Teachers Class. A pretest/posttest/Control Group design was implemented.

Session C-3

FACTORS AFFECTING THE PERSISTENCE OF WOMEN UNIVERSITY STUDENTS IN SCIENCE AND TECHNOLOGY

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ABSTRACT

The purposes of this study, carried out at the main campus of a landgrant university in the northeast, were twofold. One was to study rates of persistence of undergraduate women students majoring in science and technology compared to that of men in the same fields over a two-year period. Students participating were sophomores or seniors in two-year or four-year programs ranging from male-dominated fields like Engineering Physics to majors such as Food and Nutrition which are taken mostly by women. The second purpose was to explore factors associated with persistence (or lack of it) in these fields, especially those factors which can be influenced by the undergraduate environment. Three areas of associated factors were chosen because they seemed intrinsically related to success in science and technology and because gender-related differences had been observed in previous research: mathematical performance, social support, and experience with machine and tools.

Some of the data were obtained from the registrar's office: college, sex, GPA, date of birth, earned credits, SATM, SATV, math and physics courses taken and grades received. The rest of the data were gathered by a three-part questionnaire assessing experience with common mechanical tasks and social support two to three semesters earlier and at the time the questionnaire was distributed. Over 600 questionnaires were mailed out and 366 usable forms were returned (62%).

Analysis of the data revealed that three groups of nonpersisters existed:

1. students who transferred out of science majors,

2. students who transferred into science majors from nonscience majors, and

3. students who switched from one science major to another.

Although the persistence rates were similar for males and females the type of transfer mode differed. Males were more apt to transfer out of science, while females transferred from one science to another or into science.

Because of the small numbers of male and female nonpersisters in each category, the types of statistical analyses were limited, and most were done through a Chi-square analysis leading to the following conclusions:

1. Male nonpersisters had poorer academic records than had the female nonpersisters as evidenced by GPA, math and physics grades.

2. Perceptions of social support by the academic staff differed for women and men as well as persisters and nonpersisters. There is even an indication that social support is more important for women than for men in their persistence in what are nontraditional majors for women.

3. The results of the mechanical experience questionnaire, while inconclusive, proved interesting. There was a tremendous gender-related difference, but this did not appear to affect either academic performance as evidenced by course grades or persistence.

The results of the study would indicate that persistence rates for women in science and technology might be enhanced by improving the academic climate for women. Recruiting more women faculty in science and technology should be a high priority for this university. More importantly, emphasis should also be placed on sensitizing existing academic staff to the (perhaps greater) needs of women students for social support.

Session C-3

THE EFFECTS OF KINETIC STRUCTURE AND MICROGRAPH CONTENT ON ACHIEVEMENT IN READING MICROGRAPHS BY COLLEGE BIOLOGY STUDENTS

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ABSTRACT

The effects of kinetic structure and micrograph content on student achievement of reading micrograph skills were examined. One hundred introductory college biology students at an eastern state university participated in the study that examined both knowledge acquisition (short-term learning) and knowledge retention (long-term learning).

Kinetic structure, defined by O. Roger Anderson as the serial order in which subject matter is presented and the relatedness of contiguous discourse units in verbal communication, was one independent variable. Students were randomly assigned to one of two treatment groups: low kinetic structure or high kinetic structure. The low kinetic structure group listened to an audiotape with B1 average value of .20 in the audiovisual tape portion of the instruction. The high kinetic structure group listened to an audiotape with an average B1 value of .45 in the audiovisual tape portion of the instruction.

Micrograph content was the other independent variable. Students were randomly assigned to one of two treatment groups: varied micrograph content or unified micrograph content. The varied micrograph content group used micrographs of Tetrahymena, Euplotes, Paramecium, Stentor, and Blepharisma during the practice sessions of the instruction. The unified micrograph content group used micrographs of Tetrahymena only during the practice sessions of the instruction.

The students received three instructional units: Reading Light Micrographs, Reading Transmission Electron Micrographs, and Reading Scanning Electron Micrographs. Each instructional unit

consisted of an audiovisual tape portion and a micrograph practice session. An achievement test was administered 48 hours after the last instructional unit to test knowledge acquisition. The same test was administered three or more weeks after the instructional unit to test knowledge retention.

The achievement measure was divided into two tests that identified the two dependent variables: understanding general concepts achievement, Test G, and reading micrographs achievement, Test RM. A repeated measures analysis on variance (MANOVA) was performed on the data.

At an alpha of .05, the effect of kinetic structure on student achievement of understanding general concepts related to reading micrographs, Test G, was significant. Time between testing, micrograph content, and the interaction between kinetic structure and micrograph content were not significant. Students receiving high kinetic structure in the audiotape of the audiovisual portion of the instruction demonstrated a greater mastery of general concepts about reading micrographs than students receiving the low kinetic structure audiotape in the audiovisual portion of the instruction.

At an alpha of .05, the effects of micrograph content and time between testing on reading micrographs achievement were significant. Kinetic structure and the interaction of micrograph content and kinetic structure were not. Students receiving unified micrograph content in the practice sessions of the instruction demonstrated a significantly greater mastery of reading micrographs than did students receiving varied micrograph content in the practice sessions of the instruction. Time between testing was a significant factor; the grand mean for reading micrographs, Test RM, was 47.65 for the knowledge acquisition test and 43.62 for the knowledge retention test. An examination of the cell means revealed a comparable loss of knowledge over time in each of the four treatment groups.

Session C-4

CHANGES IN TEACHERS' ACHIEVEMENT IN SCIENCE AND ATTITUDE TOWARD TEACHING SCIENCE DUE TO MATCHING AND MISMATCHING SCIENCE ACTIVITIES WITH LEARNING STYLES

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ABSTRACT

The purpose of this research was to examine the effects on achievement and attitude of the interaction between specific types of learners as assessed by The Myers-Briggs Type Indicator (MBTI) and science learning activities designed to correspond to MBTI types.

A simplified model of the MBTI with four types was used: sensing-feeling (SF), sensing-thinking (ST), intuitive-feeling (NF) and intuitive-thinking (NT). Of the 96 elementary teachers who participated in this study, 56 were SF learners while the remaining 40 were non-SF types (ST, NT and Nf types).

Since the majority of teachers were of the SF type, the science activities that were matched to the teachers' type exhibited SF qualities. On the other hand, the science activities that were mismatched to the teachers' type had characteristics of the NT type. A Validation Committee rated each activity according to the degree the activity exhibited "SFness" and "NTness."

Fifty-three teachers used the activities matched to the SF type, while 43 teachers used the activities mismatched to the SF type.

All participants took the following tests:

1. Myers-Briggs Type Indicator (MBTI).
2. Science Knowledge Pretest and Posttest (SKT).
3. Attitudes Toward Science and Science Teaching Pretest and Posttest (ATSST).

4. Attitudes Toward Learning Activities (ATLA) following each activity.

A multivariate analysis of variance (MANOVA) was run on the data and no significant differences between treatment groups on the SKT and the ATSST were found.

Even though univariate analysis of variance on the ATLA did not reveal significant differences for SF and non-SF types, internal analyses were done on individual activities with Duncan's post hoc test. The results showed that the activities that were rated as being well matched to the SF type by the Validation Committee received significantly more positive ratings by SF types than by non-SF types. Likewise, if activities were rated as extremely mismatched to the SF type then they received significantly less positive ratings by SF types than by non-SF types. It would appear that a person's attitude toward a learning activity can be improved by designing learning activities which are well matched to a student's type.

Session C-4

TEACHER MANAGEMENT AND STUDENT ENGAGEMENT IN HIGH SCHOOL SCIENCE

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ABSTRACT

The paper describes a study conducted in science classes from grades 8 to 12 in two high schools in the metropolitan area of Perth, Western Australia. The purpose of the study was to investigate science teachers' roles in managing student discipline and in promoting and maintaining a productive learning environment. The three types of intact classes were involved in the study: unstreamed grade 8 classes, streamed classes in grades 9 and 10 formed on the basis of science ability, and classes that comprised students who had elected to study additional science in grades 11 and 12. Each of the 15 teachers involved in the study was observed on several occasions with at least three classes from two or more of the above categories.

Broadly speaking, teachers managed the pace and type of activities and the type of student engagement to ensure that the planned work was completed. As a consequence, teachers taught in a whole class interactive mode for a significant proportion of the time and tended to interact with a limited set of "target" students. Thus, most students were not overtly engaged. There was also a tendency for teachers and students to adopt strategies that resulted in a reduction in the cognitive demands of the academic work. These observed strategies were consistent with the overall hypothesis that the focus for science instruction was on completing the academic work (covering subject matter content) rather than on teaching and learning science. The paper also discusses management of laboratory activities and activities that involved students in an individualized form of engagement.

Session C-4

MEASURING THE EFFECT OF INQUIRY SCIENCE INSERVICE EDUCATION ON PARTICIPANT TEACHING METHODOLOGY AND ON KNOWLEDGE ORGANIZATION AND COGNITIVE PERFORMANCE LEVEL OF ELEMENTARY SCHOOL STUDENTS

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ABSTRACT

Research has helped to identify the fundamental skills that should be developed in an inquiry science program: observing, describing, comparing, classifying, using numbers, measuring, interpreting evidence, inferring, predicting, and experimenting. An NSF-sponsored inservice workshop was designed to help elementary school teachers develop these skills.

Participating teachers were instructed in the learning theories of Piaget and the developmental levels of their students. The workshop provided the teachers with experiences to help them develop classroom environments conducive to implementation of an inquiry science program. A teaching procedure, the "learning cycle," actively involved them in experimentation, discussion of scientific processes, and scientific record keeping and data analysis. The workshop experiences also prepared the teachers to match their teaching procedures with the level of intellectual development of their students.

The workshop participants were matched with a control group of teachers who utilized the exposition method (reading and memorizing science concepts) when teaching science. A pretest-posttest design was used to measure the effects of the inservice workshop on participant teaching methodology and ultimately on the knowledge organization and cognitive performance level of their elementary school students. The students were interviewed utilizing three Piagetian tasks (liquid, length, and weight) and six objects (a magnet, a cotton ball, a marble, a seashell, a wooden square and triangle, and three bars of differing materials) which they were to describe. Comparisons between the experimental and control groups were made noting the usage of property words, organization of information or knowledge, and willingness to talk.

The nature of this research involves a thorough analysis of both the classroom environment and the student interviews. For these reasons, an anthropological approach will be used for data analysis. The data collection will be completed May, 1985.

Session C-5

RELATIONSHIPS BETWEEN FORMAL-OPERATIONAL THOUGHT AND CONCEPTUAL DIFFICULTIES IN GENETICS PROBLEM SOLVING

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ABSTRACT

Seventy-one college general biology students were taught a unit in Mendelian genetics by the traditional lecture method. Emphasis was placed on meiotic formation of gametes, the Law of Dominance, the Law of Segregation, and the Law of Independent Assortment. The Punnett square model was used for all practice problems. To build Punnett squares, students were required to identify the gamete types that could be produced by parent organisms; they were then asked to identify phenotype and genotype ratios from the resulting zygotic combinations. Estimations of the probability for gamete formations or zygote combinations were also required in practice problems. A unit test was followed, eight weeks later, with a content validated post-test to evaluate the students' retention of problem-solving skills. Both tests required students to use proportional reasoning (identifying ratios from the Punnett squares), combinatorial reasoning (identifying combinations of gametes from parental genotypes), and probabilistic reasoning (estimating gamete or offspring probabilities). Each of the seventy-one students was also given three Piagetian interview tasks to evaluate his intellectual development in the areas of reasoning under question. The balance beam task, the electronic switch-box task, and colored squares and diamonds were used to test for proportional reasoning, combinatorial reasoning, and probabilistic reasoning respectively. Pearson correlations and factor analysis failed to show direct relationships among Piagetian tasks for the three kinds of reasoning and their corresponding occurrence in genetics problems. Some correlations were higher between different reasoning types than between similar types. Combinatorial with proportional reasoning on the post-test and interview tasks had a correlation of .44, while proportional with proportional from the same tests

correlated at .32. Analysis of variance showed significant differences for all three reasoning types among concrete-operational, transitional and formal-operational students in both the unit test and post-test. Post hoc analysis of ANOVAs indicated that formal-operational students had significantly more success in the three reasoning areas than transitional students, and transitional students had significantly more success than concrete-operational students.

Session C-5

MEASURED FORMAL THOUGHT AND THAT REQUIRED TO UNDERSTAND FORMAL CONCEPTS IN COLLEGE LEVEL PHYSICAL SCIENCE

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ABSTRACT

In The Growth of Logical Thinking, Piaget and Inhelder describe the operations and schemata which are postulated as being the characteristics of formal operational thought. Those formal thought characteristics, therefore, are used in solving problems which require formal thought. The hypothesis can be made, therefore, that persons who possess certain characteristics of formal thought will do better on tasks judged as requiring those characteristics than those persons who do not possess them.

Using the individual interview technique, 49 students enrolled in a physics course for elementary teachers were evaluated for their abilities to use combinatorial logic, separation and control of variables, proportional reasoning, and reciprocal implications. The performance of each student in the interviews was treated as a measure of the degree to which that student could function with those four formal-thought characteristics.

During one semester the students were given experience with 30 physics concepts using the learning cycle. Six of those concepts dealing with torque, electricity, optics and heat were used in the research. Understanding those concepts required using one or more of the characteristics of formal thought given earlier. Questions to measure the understanding of each concept were written and content validated. The validated questions were inserted into the five course examinations at the proper time during the semester. The students' success on the questions was treated as a measure of their abilities to use the characteristics of formal thought in problem solving. Data were available, therefore, on the formal thought characteristics the students

possessed and their abilities to use those characteristics in problem solving.

A total of 52 correlation coefficients was computed between the ability to use the formal thought characteristic in solving a problem and to demonstrate possession of those characteristics. Only eight of the correlation coefficients were statistically significant and the largest was 0.34. The conclusion was drawn that a non-significant relationship exists between the formal thought characteristics required to solve a problem and demonstrating the possession of those characteristics. When success on each of the interview tasks was correlated with success on each of the other tasks, all the coefficients were statistically significant and moderately high. That finding led to the conclusion that success on a problem which requires formal thought depends upon an overall formal-thought structure.

Session C-5

MEASURED FORMAL THOUGHT AND THAT REQUIRED TO UNDERSTAND FORMAL CONCEPTS IN SECONDARY SCHOOL BIOLOGY

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ABSTRACT

In The Growth of Logical Thinking, Piaget and Inhelder describe the operations and schemata which are postulated as being the characteristics of formal operational thought. Those formal thought characteristics, therefore, are used in solving problems and responding to questions which require formal thought. The hypothesis can be made, therefore, that persons who possess certain characteristics of formal thought will do better on tasks judged as requiring those characteristics than those persons who do not possess them.

Using the individual interview technique, 22 students enrolled in secondary school biology were evaluated for their abilities to use combinatorial logic, correlation reasoning, separation and control of variables, exclusion of irrelevant variables, proportional reasoning, and probabilistic reasoning. The performance of each student in the interviews was treated as a measure of the degree to which that student could function with those six formal-thought characteristics.

The research began by preparing several biology questions which required one or more of the foregoing six formal operations in responding satisfactorily. The questions were content validated and the operations required were also judged. Both validations were done by panels. Only two questions survived both validations.

Question One was judged to require correlation reasoning, combinatorial logic, separation of variables and exclusion reasoning. The 22 students, therefore, could have shown formal thought 88 times; only 24 such instances were found. Question Two was judged to require combinatorial, probabilistic and proportional reasoning and the separation of variables. Again it was possible to demonstrate formal thought on Question Two 88

times; formal thought was demonstrated 25 times. At no time were the specific formal operations indicated by the panel as being needed to solve Question One used by the 24 students who demonstrated on the tasks they could use those specific operations. Only seven times -- of 25 possible -- on Question Two were the specific formal operations used that were cited by the panel as being necessary to produce a satisfactory response to that question. In a very few cases formal thought was demonstrated on the questions but had not been demonstrated during the interview. Those few deviations will be treated in the presentation.

In view of the data cited earlier, the conclusion was drawn that using specific formal operations with which students demonstrate they can function, is not a good predictor of success on a question whose satisfactory response requires those specific formal operations. The explanation for that conclusion, we believe, is found in the fact that, with one exception, success on the interview tasks are highly correlated with each other. That piece of empirical data points to the unity of formal thoughts.

Session C-6

A CAUSAL MODEL FOR THE DEVELOPMENT OF SCIENTIFIC REASONING IN ADOLESCENTS

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ABSTRACT

This disseration research involved the formulation and testing of a model for the development of scientific reasoning abilities in adolescents. Several potential determinants included within the model were chosen based upon the interpretation of Piagetian theory regarding the development of formal operational thought in adolescents. Causal relationships among potential determinants and with the ultimate dependent variable of interest, Scientific Reasoning, were hypothesized a priori with strong theoretical and heuristic considerations and with support from the results of previous empirical studies.

Variables in this study (and their corresponding instruments) were as follows: Experience (Cognitive and Recreational Activity Scale); Locus of Control (Intellectual Achievement Responsibility Questionnaire); Field Dependence-Independence (Concealed Figures Test); Rigidity/Flexibility (Breskin's Ridigity Test); IQ (Short Form Test of Academic Aptitude); Gender; Age; and Scientific Reasoning (Scientific Reasoning Test). The instruments and a background data sheet were administered to intact classes of middle school (n=106) and high school students (n=96) from an upper middle-class suburb of Columbus, Ohio.

Hypothesized relationships among variables within the posited model for Scientific Reasoning were tested by path analysis. Multiple regressions were performed according to path analytic methods in order to acquire standardized beta weights for each of the hypothesized paths. These beta values were used as path coefficients for each of the posited relationships.

Significant ($p < 0.05$) path coefficients were obtained for these variables and Scientific Reasoning: Age, IQ, Field Dependence-Independence, and Experience. Age and IQ (with path coefficients of 0.54 and 0.49, respectively) were stronger determinants of Scientific Reasoning than were Field Dependence-Independence (0.15) and Experience (0.11). An indirect

effect of Locus of Control on Scientific Reasoning through the Field Dependence-Independence variable was also supported, with an obtained path coefficient of 0.28 between Locus of Control and Field Dependence-Independence. None of the paths involving Gender or Rigidity/Flexibility were statistically significant, and these two variables were removed from the revised model. The final model, which included only variables for which there were statistically significant path coefficients, explained 61 precent of the variance in Scientific Reasoning.

On the basis of these findings, suggestions are made regarding further research and appropriate interventions which may influence and/or enhance the development of scientific reasoning abilities in adolescents.

Session C-6

VALIDATION OF HIERARCHICAL RELATIONSHIPS AMONG PIAGETIAN COGNITIVE MODES AND INTEGRATED SCIENCE PROCESS SKILLS FOR DIFFERENT COGNITIVE REASONING LEVELS

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ABSTRACT

In the past, attempts in relating the Piagetian cognitive modes and integrated science process skills have been correlational in nature. A hierarchical linkage among the Piagetian cognitive modes and integrated science process skills together with the methodology has been proposed. Since students in different Piagetian cognitive reasoning levels operate differently in their thinking, it appears reasonable to hypothesize that the hierarchical linkage at each level may be different. The methodology used previously was psychometric in nature. While it may be satisfying to determine hierarchies using psychometric methodologies, it should be more helpful and useful to science educators to determine whether the attainment of subordinate skills can help facilitate attainment of superordinate skills based on previous psychometrically determined 'best' hierarchy. This procedure of determining whether attainment of subordinate skills facilitates attainment of superordinate skills has been termed vertical transfer validation.

Thus the purpose of this study was to determine and compare the 'best' fit hierarchy among the Piagetian cognitive modes and the integrated science process skills for each of the Piagetian cognitive reasoning levels: concrete, transitional and formal. Furthermore, we were interested in determining whether the best-fit hierarchies were confirmed by the vertical transfer validation method.

Seven hundred and forty-one middle and high school science students in grades 7 to 12 participated in this study. The gender proportion in the sample was quite even, with 384 males and 355 females. One hundred and thirteen students were categorized at the formal level of cognitive reasoning, 162 at the transitional level and 466 at the concrete level.

The best-fit hierarchies for the concrete and transitional reasoning levels were obtained. The data from the transfer validation procedure suggest that at the concrete reasoning level and given the necessary prerequisites: (1) review on designing experiments can facilitate the achievement of identifying hypotheses; (2) review on operational defining can then facilitate the attainment of identifying hypotheses; (3) review on both operational defining and designing experiments can facilitate the attainment of identifying hypotheses; and, (4) review on proportional reasoning can facilitate the attainment of probability reasoning.

Presently, there is no evidence to support vertical transfer of skills at the transitional reasoning level.

Science curriculum developers, instructional designers, teachers, teacher trainers and researchers need to be aware of the link and interdependence of both sets of skills. Furthermore, they need to be aware of the exact nature of the hierarchy for different cognitive reasoning levels. Science education researchers need to put more effort into this type research so that the hierarchies obtained can be further refined.

REASONING TEST

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ABSTRACT

This study was an investigation of the concurrent validity of two tests of cognitive development: one being task interviews on ten operational measures of cognitive development described by Jean Piaget; the other, corresponding operational measures contained in the Reasoning Test, developed by Paul Ankeny and Lyle Joyce (1975). The Reasoning Test is a group instrument consisting of 30 objective questions which purports to provide an alternative to the individual Piagetian task interviews. The operations assessed were: conservation of weight, conservation of length, conservation of area, conservation of volume, one-to-one correspondence, class inclusion, transitivity, Euclidean space, spatiality, and velocity. Subjects in the study were 50 fourth graders randomly selected from a population of approximately 150 students from a middle class agricultural community in northeast Nebraska. The I.Q. was 110.9 with standard deviation of 11.6. Subjects included 27 females and 23 males. The Reasoning Test was administered in two one-hour sessions. The questions were read orally in addition to providing each student with a printed copy of the instrument. A series of task interviews, one task for each of the 10 concepts selected in the Reasoning Test, were administered to each subject individually. Interview sessions were normally conducted in a period of 12-15 minutes.

A cross-tabulation of the number of task interviews achieved compared with the number of concepts achieved on the Reasoning Test resulted in a correlation coefficient of .46. This indicates a moderate, positive relationship between the two types of tests. An analysis of the categorized data yielded a correlation coefficient of .11. Subjects were categorized as concrete operational if they demonstrated competency on eight or more of the ten operations assessed. The criterion level for categorization was established using the recommendation established by Paul Ankeny and Lyle Joyce, developers of the Reasoning Test. According to performance on both the Piagetian task interviews and the Reasoning Test, many fourth graders were still pre-operational. Five students (10%) were classified as concrete operational using the Reasoning Test, while 32 (64%) students met the necessary performance criterion on the task interviews. An area needing further research reflected in this

study is an apparent discrepancy between cognitive level using task interviews as compared to a group test. In this study, a significantly larger portion of students demonstrated concrete operational thought process on task interviews as opposed to printed oral questions reflecting the same operations.

Session C-7

HUMAN AND MACHINE DIAGNOSIS OF SCIENTIFIC PROBLEM-SOLVING ABILITIES

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ABSTRACT

The purpose of this long range study is to find answers to the following questions: (1) How does an accomplished science teacher diagnose the problem-solving ability of a student during an individual help session; and (2) Can this diagnosis be simulated by a machine?

Methods used are similar to those used by researchers who have developed expert computer systems that simulate human experts, particularly in the field of medical diagnosis with systems such as MYCIN and CADUCEUS. An interdisciplinary team of faculty and students work together using procedures including:

1. Discuss with experts (scientists/teachers) the general diagnostic procedures they use in trying to help students on an individual basis.

2. Videotape diagnostic sessions and discuss with the expert what was happening and why.

3. Determine what seems to be the content knowledge and heuristics needed to solve specific science problems.

4. Analyze the procedures used by experts and novices as they attempt to solve science problems.

These psychological-type data are then used by the team of researchers to build a computer system that simulates the expert diagnostician. In this project (DIPS for Diagnosis for Instruction in Problem Solving), the fuzzy logic system of Zadeh is used to manage the uncertainty contained in the natural language input of the user. Many of the other procedures used to build the DIPS system are similar to those described in detail in Building Expert Systems by Hayes-Roth, Waterman and Lenat.

Progress on this long-term research project thus far can be summarized by the following points:

1. An important part of the effective teaching of problem solving in science is diagnosis of a student's initial problem-solving state.

2. The success of various medical diagnostic expert systems suggests that similar systems are possible for diagnostic purposes in education.

3. A common technique used by human experts (accomplished science teachers) during a diagnostic interview with a student is a combination of problem posing and question asking. The diagnosis is usually interwoven with attempts at teaching.

4. A typical mechanics chapter in a high school physics text contains about 5000 words, including about 800 unique words. Of the unique words, only a few such as velocity, acceleration, force, inertia, momentum, translatory, Newton, centripetal, centrifugal, slug and dyne can be considered to be uniquely in the domain of physics. This suggests that the DIPS system can operate with about 1000 words in its dictionary.

5. Graphics capability is extremely important in the communication between the teacher (diagnoser) and student about mechanics problem solving. This is very likely true for a wide variety of standard problems in various science content areas.

6. The imprecise or fuzzy nature of language in normal human communications requires an appropriate logic (Zadeh's fuzzy logic in this case) to handle the uncertainty in the diagnostic interview.

7. Natural language processing must be kept to a minimum and "user-friendly" techniques to a maximum in DIPS-like systems.

Session C-7

THE EFFECTS OF TEACHING AN INFORMATION PROCESSING APPROACH TO PROBLEM SOLVING ON MATHEMATICAL CHEMISTRY ACHIEVEMENT OF COLLEGE STUDENTS

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ABSTRACT

Students enrolled in a preparatory college chemistry course at the University of Maryland, College Park were randomly assigned to treatment or control groups for one semester. The two groups attended lectures simultaneously in adjoining lecture halls. The control group was taught dimensional analysis as its problem solving strategy in dealing with mathematical chemistry problems. The treatment group was taught an explicit approach based upon the information processing model of problem solving.

Achievement for both groups was measured on three regularly scheduled hourly tests given during the semester and on the final examination. Students' mathematical chemistry problem and non-mathematical chemistry content subscores were determined for one preselected chemistry topic per test. These topics included density, mole-based conversions, and stoichiometry. The final examination subscore was a cumulative measure of all three topics. Two covariates were used in this study -- Logical Mathematical Reasoning pretest and the College Board Scholastic Aptitude Mathematic Test (SAT-M).

The results were analyzed using a multivariate analysis of variance procedure (MANOVA). No significant difference was found at the .05 significance level in the mathematical chemistry achievement of those students who received instruction in the explicit problem solving approach and those who were taught dimensional analysis as their problem solving approach.

The control group's pretest scores showed a significantly higher correlation to achievement scores than did the treatment group's scores. Statistically equivalent positive correlations were found between chemistry content and mathematical chemistry achievement for both groups.

A significant negative correlation was found between pretest scores (Logical Mathematical Reasoning Test) and extent of explicit problem solving approach use within the treatment group.

A significantly higher mathematical chemistry achievement level ($F = 3.17$, $p = .046$) was found to exist for the treatment group on the first test. Forty-four percent of the treatment students showed written evidence of having used the explicit problem solving approach on this first test. This percentage of students using the explicit method was higher than for any other test or the final examination.

Fifty-four percent of the treatment students answering an end-of-semester questionnaire reported that the explicit approach to problem solving used in this study was too time consuming. Only 12% of the control students answering the same questionnaire reported that their problem solving approach (dimensional analysis) was too time consuming.

Session C-7

A NEUROLOGICAL MODEL OF PROBLEM SOLVING AND INTELLECTUAL DEVELOPMENT

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ABSTRACT

A neurological model of the acquisition and deployment of higher-order cognitive strategies is advanced. The model is based upon Grossberg's neural modeling principles of learning, perception, cognition, and motor control. Thus, the model attempts to explain aspects of higher-order problem solving and intellectual development based upon principles found applicable to events at the level of individual neurons and neuron networks. The method employed is to discuss basic neurological principles, as applied to classical conditioning and to the acquisition of the relatively simple action of a child learning to suck milk from a bottle. The neuronal networks developed to explain this behavior will then be applied to the higher-order shift in problem solving behavior from the child's incorrect use of an additive strategy to the adolescent's correct use of a proportions strategy to solve problems of quantitative proportional relationships. Piaget's process of psychological equilibration will be explicited and general educational implications will be drawn.

Session C-8

HIGH SCHOOL GRADUATES' VIEWPOINTS ON SCIENCE-TECHNOLOGY-SOCIETY TOPICS

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ABSTRACT

Overview

The purposes of this study were (1) to monitor student understanding of science-technology-society (STS) topics; and (2) to do this in a unique manner that might lead to a new generation of standardized instruments that would describe student viewpoints on STS issues.

A sample of 10,800 graduating high school students came from a stratified sampling of classrooms from across Canada, one part of the Canadian IEA evaluation study. Each student was asked to respond to a statement concerning a STS topic by (1) stating whether he or she agreed with the statement, disagreed, or couldn't tell; PLUS (2) writing a paragraph explaining the reasons for the choice.

The statements came from an instrument comprising 46 items based on 16 major topics found in the epistemology and sociology of science literature. Each student in a classroom reacted to a different statement. Thus, out of the 10,800 student responses, about 236 addressed one of the 46 statements. A random 30% of these were analyzed to tease out common viewpoints held by students.

Findings

A general and important methodology point emerged. The meanings students ascribe to a statement are often very different

from the meaning teachers and researchers ascribe to the same statement. This result questions the validity of the conventional manner of interpreting student responses to "objective" standardized instruments or questionnaires.

Among the many findings, the following are offered as typical examples. These are organized around three conceptual themes:

(i) Interactions Among Science, Technology and Society. Students were asked to respond to statements based in either a technocratic or democratic view of socioscientific decision making. Reactions to the statement that "the political climate of Canada has little effect upon Canadian scientists" centered on the issue of government funding and research policy. Surprisingly insightful arguments suggested that since most research was funded by government, government would control the way funds were to be spent. As well, government policy towards technological development was seen as affecting a scientist's choice of research topics.

(ii) Characteristics and Limitations of Scientific Knowledge. Students offered a wide range of responses to the statement that "many scientific models ... are metaphors or useful stories; we should not believe that these models are duplicates of reality." Those agreeing with the statement argued, for example, that models are just helpful and useful for learning and explaining. Those arguing against the statement based their arguments in scientism. A third argument relied on the belief that "authorities (experts, teachers, and texts) say they are true."

(iii) Characteristics of Scientists. The statements on this topic were designed to solicit responses from students on how they view the scientist as a person and how this might affect the knowledge generated by that person. The responses showed considerable sophistication when reacting, for example, to the idea that "the best scientists follow the steps to the scientific method." with many students stressing the importance of originality and the need to transcend any one method. Perhaps the most passionate responses were reserved for reacting to statements concerning the higher proportion of male scientists in Canada in comparison with the number of female scientists. Both male and female students gave as a common reason the different socialization paths experienced by boys and girls.

COMPARATIVE EFFECTIVENESS OF INSTRUCTIONAL STRATEGIES ON DEVELOPING THE CHEMICAL MOLE CONCEPT

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ABSTRACT

The purposes of this study were to determine for students enrolled in a freshman chemistry program if the type of instructional strategy used influences (1) learning of the mole concept, and (2) the level of students' misconceptions concerning selected concepts related to the mole.

Three instructional strategies derived from Piagetian and Ausubelian theories was implemented in an urban community college with freshmen chemistry students. One instructional strategy, the learning cycle, was derived from Piagetian theory and is a three-phase process: (1) exploration, (2) invention, and (3) discovery. The second instructional strategy, cognitive learning and development, was developed by Klausmeier based on Ausubelian theory. This strategy consists of presenting a formal definition of a concept, a list of critical and variable attributes, and a list of examples and nonexamples. The third instructional strategy, lecture-laboratory, consists of presenting the concept in an expository format in a classroom setting. The student verifies the lecture materials in a laboratory setting by performing experiments from carefully described procedures.

An ex post facto, pretest-posttest, control group design was used to determine experimentally the nature of the relationship between teaching methodology to achievement level and misconception level in selected chemistry content.

Three instruments were used in this study: a math achievement test, Burney's "Piagetian Objective Formal Instrument," and the Achievement and Misconception Test (AMT). Additionally, students constructed concept maps and Gowin Vees based on laboratory and lecture materials.

The sample consisted of 60 students enrolled in the Fundamentals of Chemistry course at an urban community college during the 1983, fall semester. Two classes were taught in the mole concept, over a period of five weeks, using the cognitive learning and development strategy (CLD). One class was taught the mole concept over the same period of time using the learning cycle. The third class used a lecture-laboratory format.

The data collected for this study were analyzed using a treatment by levels design where the students were matched on the basis of pretest scores. A three-way factorial analysis of variance with repeated measures was used to analyze the data.

The results of this study indicate that, for this sample, the three methods were equally effective when used to teach various aspects of the mole concept. The results further indicate that the three methods were equally effective in bringing about conceptual changes in which knowledge concerning mass and volume as well as the particulate nature of matter matched the knowledge structure of experts in this area.

Student responses indicated that many students viewed matter as being continuous. Students also viewed the removal of air from a flask as leaving an empty space in the flask.

Confusion concerning the difference between mass and volume was also noted.

Session C-9

AN ANALYSIS OF TRADITIONAL REPRESENTATIONS OF SCIENTIFIC KNOWLEDGE FROM THE POINT OF VIEW OF AUSUBEL'S THEORY OF LEARNING

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ABSTRACT

Representations of scientific knowledge in secondary school science curricula result from translating raw knowledge as it appears within the context of discovery to "public knowledge" within the context of justification. This reformulation reflects underlying epistemological assumptions on the nature of scientific knowledge.

The resulting conceptual structure is analyzed from the point of view of Ausubel's learning theory. Attention is focused on two characteristics of this structure: the arbitrariness of concepts and the supression of very inclusive ideas which could play a role as subsumers. According to the analysis, these characteristics are seen as consequences of:

a. Nonexistence of problems: Concepts in science are not introduced merely as logical possibilities which could enlarge the content of a discipline but as a response to some outstanding problem. Customarily science courses and textbooks do not provide the student with the problems but with the answers, that is, explanatory concepts and principles.

b. Inductivist structure: Scientific concepts result from a psychogenetical stage, the production in the mind of the creative scientist, and, later, an evolutionary process. Hiding this from the student results in presenting artificial constructs whose only justification supposedly lies in the facts or phenomena being explained.

c. Nonexistence of metaphysical beliefs: Science students learn results as if they were a product of inspirations taking place in an absolute ideational vacuum. Consequently, ideas which appear along history strongly linked to global conceptions of the researcher (themata, ideals of natural order, metaphysical beliefs) are stripped from any metaphysical trace and presented as results coming from nowhere.

Finally, a proposal is made to devise representations of conceptual knowledge leading to improved meaningful learning.

First, to improve the nonarbitrariness of conceptual links, the obsolete empiricist theory of knowledge underlying traditional science curricula should be abandoned. Concepts, in its final form, should be presented as nonarbitrary responses to problems which science faced along history. What is being proposed, at the epistemological level, is to introduce genetic epistemology as a background to better representations of scientific knowledge with teaching purposes.

Second, it is necessary to make a connection with the most stable and general ideas of the learner. This implies looking for ways of establishing correspondence between the ideas which made science intelligible to scientists along history and the ideas which make science intelligible to our students.

Session C-9

AN EVALUATION OF THE SCIENCE - A PROCESS APPROACH FOR TRINIDAD AND TOBAGO (SAPATT) PROGRAM

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ABSTRACT

The Science-A Process Approach for Trinidad and Tobago Curriculum developed from 1977-1984 is currently being used in Grades K-7 in all public schools. This study attempts to evaluate the attainment of the program's major objectives in terms of the children's ability to use the process skills after six years exposure to the program. Some attempt is made to measure children's interest, active involvement, achievement in the lesson, as well as teacher's enjoyment in teaching the lessons, their opinion of the teacher's guide, the availability of material and the teachers perceived need for supplemental reading material, student workbook and further training. Data were collected by means of a process test given to the children and a teacher opinionnaire. The experimental group comprised 290 public school students, while the control group comprised 258 private school students. Their results on the process test were compared. Seventeen (17) public school teachers who had been involved in the development of the curriculum and who were now teaching it completed the opinionnaire. The results indicated that children who have been exposed to the six-years of SAPATT scored considerably higher than those who were taught science using a content rote memorization approach. The t-test, F-ratio and X^2 value were all significant at the .001 level of significance.

Session C-10

A META-ANALYSIS OF LEARNING SCIENCE CONCEPTS FROM TEXTUAL MATERIALS

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ABSTRACT

This study utilized meta-analysis techniques to analyze the effects of different types of aids on learning science concepts from textual materials. The studies analyzed dealt with aids for selecting the important information contained in written materials and aids for building internal connections among the parts of printed materials. Thus, studies which pertained to advance organizers and to student elaboration activities were not considered. The relevant research studies were identified through a search of several data bases. Additionally, the yearly reviews of research published in Science Education were utilized.

Relevant characteristics of the research studies were identified and coded. Coding of these characteristics allowed the uniform examination of differing design features, dependent variables, and outcomes. These identified features were used to block the studies so that the meta-analysis procedure could be focused upon several important research study variables.

The analysis of the research studies produced various results. First of all, the overall average effect size indicated that students may be aided in their understanding of science concepts from textual materials. The overall effect size was positive. Second, the effect size varied considerably depending upon the type of dependent measure. Last, the results of blocking the studies on other variables was not clear. Many of the computed effect sizes were small.

Learning from textual type materials and learning from laboratory type situations will always be two integral parts of science education. Today, with the microcomputer being used to simulate many laboratory type activities, knowledge about learning from textual type materials may possibly become more important. The present study indicates that most students can be expected to benefit from forms of textual structuring that aid them in selecting the important concepts and that also aid them in making internal connections within the presented materials. It is possible that computer presentation of textual materials will make

this even more feasible. This paper also discusses the research questions yet to be studied when we consider learning science content from printed materials.

Session C-10

WHAT RESEARCH SAYS ABOUT HEALTH EDUCATION: REPORT ON A META-ANALYSIS OF NUTRITION EDUCATION

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ABSTRACT

Health education has been neglected in U.S. Schools. In the elementary school setting, science education and physical education have been playing a game of "give-away", each trying to get the other discipline to take health as a topic. In the secondary area, it has been an also-ran class or nonexistant. Yet, personal health remains one of the more important and intrinsically motivating topics in our society.

The 1976 NAEP survey of 17-year-olds and adults indicated that a significant portion of people's knowledge in the health area comes after students leave school and that up to a third of the 17-year-olds could not pick a nutritious breakfast from examples or knew what kind of foods produced quick energy. Even more significant, the expert comment on the report reminded readers that although people tend to be somewhat knowledgeable in the area, they do not act on that knowledge.

This meta-analysis reviewed nearly 300 studies in the area of nutrition education and also examined the effects of a number of the characteristics used in the studies on results (including age of subjects, random assignment of subjects, length of study, etc.). Three methods of meta-analysis were used: a voting method where each of the 3,897 findings were coded as negative impact, no impact, and positive impact of instruction on nutrition knowledge, behavior, or attitudes; effect size comparisons; and a z-score wherever enough information was given to do so.

The review indicates that nutrition education does promote more knowledge about nutrition practices, more positive attitudes toward good nutrition and more appropriate nutrition behavior. Although some of the characteristics did turn out to be

significant in their influence on the data (length of time, training of instructors, etc), there was not enough information in many of the studies to look at internal characteristics with care. However, a theory was developed from the synthesis of research for explaining how a nutritional program might work to influence knowledge, attitudes and behavior. The factors which seem to have influence on effectiveness of nutrition programs are:

1. Active involvement of participants.
2. Amount of instruction.
3. Knowledge of instructors.
4. Vivid and personalized information.
5. Structured curriculum.
6. Focus on nutrition in general rather than very specific focus.
7. Assessment of participants' nutritional needs and use of this information in program.
8. Use of small groups.

Session C-10

A FACTOR ANALYSIS OF THE SCIENCE TEACHER INVENTORY OF NEED: RECOMMENDATIONS AND MODIFICATIONS

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ABSTRACT

The Science Teacher Inventory of Need (STIN) was developed specifically to assess the perceived needs of science teachers in developing nations. During that process, a factor analysis was completed post hoc with data from a heterogeneous population of Jordanian science teachers to gather evidence of construct validity. The present study was conducted to further clarify the factorial composition and construct validity of the STIN. Data collected from 1162 (78% returns from a 20% randomized, cluster sample of) Malaysian secondary science teachers was factor analyzed via the principle components method with varimax rotation. Six nontrivial factors accounting for 91.9% of the total variance were identified. While 72 of the 76 closed items of the STIN were found to be interpretable, their rearrangement is suggested. Confirmatory factor analysis is suggested to test the obtained factor structure. In the interim, the extant data on STIN reliability and validity warrants its continued use to assess science teacher perceived needs.

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